REPORT

ON

STANDARDS

OF

WEIGHT AND MEASURE;

TO THE

GOVERNOR OF MARYLAND:

BY

J. H. ALEXANDER,

Late Engineer of the State.

BALTIMORE:
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1846.

Ye shall do no unrighteousness in judgment, in mete-yard, in weight, or in measure. *Levit.* xix. 35.

But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have; that thy days may be lengthened in the land which the LORD thy GOD giveth thee. *Deut.* xxv. 15.

HIS EXCELLENCY

THOMAS G. PRATT,

GOVERNOR OF MARYLAND:

SIR,

I have the honor herewith to present to your Excellency, a Report upon the Standards of Weight and Measure legalized by Congress, and disseminated by its authority among the several States of the Union; and, principally, upon the construction of the Measures of Length for the State of Maryland, which have been executed under my direction conformably to the said Standards, and are now ready to be delivered.

This Report and the construction of such Measures of Length—the Standard Yards—are, both, in part fulfillment of the aim of distributing the United States' Weights and Measures to the several Counties of this State; under authority of a resolution of the General Assembly, and by appointment of your Excellency's Predecessor.

As far as that appointment is concerned, the aim will be fully attained in the farther construction of a proper number of standard copies of the Weights and Capacity-measures; which yet wait to be undertaken.

Your Excellency is well aware that such a work, in its nature, requires time; and that the execution of the portion of it now completed, has been still farther delayed by causes which were without my control. I should have esteemed myself more fortu-

nate, if the circumstances of the delay could have contributed to a closer revision and perfection of the results.

But as they are, I allow myself to hope that nothing will be found to have been neglected (consistent with the object in view) belonging to accuracy of research or exactitude of execution; and that the methods (in some respects, new) which have been employed, will be recognized as fitting the present Maryland Standards fully to the use for which they were designed, and even to any other scientific or practical purpose.

I beg your Excellency to accept my assurances of

Most profound respect,

J. H. ALEXANDER.

Baltimore, 13 *Dec.* 1845.

REPORT.

THE Establishment of a system of Weights and Measures belongs not merely to the domain of mechanical science, but enters also into the regions of metaphysics and the higher generalizations of history. How we possess and employ the abstract idea of *Size* and *Weight*, whence it is that this primitive conception has come to be applied with comparatively such identity in the successive generations that have peopled our globe, and in what manner both the idea and its application may be harmonized with our other physical perceptions, are, for instance, topics of deep interest to those who busy themselves with investigations upon the intellectual and moral constitution of our race: while, of daily reference and use in individual and social transactions, the

Weights and Measures of communities,—separated, it may be, by half the circumference of the earth or by still more impassable barriers in the lapse of ages,—serve the philosophical historian, when he has examined and compared the derivations and combinations in the respective systems, the character of their units, the adaptation of them to common use, and the means employed for their exemplification and perpetuation, as so many indications of the state of human society in the respective places and times and thus of the progress and triumphs of Civilization.

If, then, the aim in the present Establishment had been to originate a new system of Standards for ourselves, it would be proper not only to have regarded the subject under the general aspects which I have mentioned (for such regard is always necessary in the application of any but the most ordinary means to the aim) but to have entered into the details and presented succinctly the results; to have verified the principles upon which an Establishment of the kind should properly rest, and which a research, as yet comparatively limited and modern, has, it is fair to say, left more undetermined than could be desired; to have pointed out the modifications, which our local circumstances (different of course for each different community) demand, either for the units or for their combination; and thus to have authenticated

the system which, if impaired or lost, would be otherwise incapable of fully identical reproduction.

But the case now with us being merely the reproduction of Standards, whose derivations have been already determined by the authority—that of the General Government of the Union—to which we, with the other several States, have confided the matter, all these preliminary investigations and settlements may be dispensed with; and the task strictly is confined to the selection and use of adequate mechanical means for imparting due accuracy and permanence to Standards, constructed upon the principles and after the patterns that have been furnished.

I suppose, then, that I shall be found to have given sufficient extension to this portion of the work, by indicating in this Report the connection of Standards of the present Establishment with the past and existing legislation of our State upon the subject of Weights and Measures—the authenticity, values, and relations of the several units which have been introduced into the system—and, finally, the details of the scientific and artistical methods which have been applied in the construction of such portion of them—the Measures of Length—as has been by this time actually executed. By this arrangement of topics, the succeeding Reports, that will be proper to be made as the remaining portions—the Weights and

Capacity-measures,—are completed in their natural order, will be merely supplemental and will contain but such a record of the operations and observations as is necessary to vouch for the correctness of the Measures themselves and the character of *standards* which is claimed for them, together with suitable instructions upon their safe-keeping and the methods in which they are to be applied to their destined purpose.

PART I.

OF THE LEGISLATION IN MARYLAND UPON THE SUBJECT OF WEIGHTS AND MEASURES.

THE *Bill for Corn-Measures*, which was passed in the Assembly of freemen of the Province, meeting in Jan. 1637, (reckoning, of course, according to the old style, by which among other things the New-Year begun to be computed on Lady-day) not quite three years after the first settlement of the Colony, has come down to us only by its title. All the Bills of this session having been vetoed by the Lord Proprietary, it was, I suppose, not thought necessary subsequently to enter copies of them upon the records. 1637.

But it may be presumed that the substance of this Bill was preserved in the *Act for Measures and Weights*, which was engrossed at the following Assembly in Feb. 1638; and which, although not actually passed, has yet been preserved in our archives. 1638.

This act provided that "there shall be one standard measure throughout the province, as shall be

appointed by the Lieut. General." It then prescribes, with particularity, how the Dry-measures of shelled-corn shall be regulated according to the age and presumable dryness of the grain; and finally interdicts the use of all weights and steel-yards not appointed by the Lieut. General, except the same be small and "sealed in England." It may be inferred upon this, that the sealing in England, which is admitted in terms to be a voucher for *small* weights, would have been equally accepted for *large* ones, had there been frequent or perhaps any cases of the importation of such costly articles for private use in the colony: and as the construction of steel-yards in general implies the adoption of an uniform measure of length, the appointment of the Lieut. General in reference to that standard, is to be interpreted as applying not to the value of the measure itself, but to the formality of its introduction and its consequent authenticity. This act may be taken, therefore, to shew what otherwise would have been naturally expected, viz: the adoption in the Colony of the then existing standards of Weight and Measure in England. The fact of such actual adoption is also demonstrated, though with a negative proof, by the non-mention of the subject in the comprehensive act (chap. ii.) of this same session, which duly became a statute. What these standards so adopted, were, will appear properly in another part of this Report.

In Aug. 1641, an *Act for Measures* prescribes that "the measure used in England called the Winchester bushel be only used" as the unit of Dry Capacity-measure. The barrel was to contain five of such bushels; and the Sheriff of each County was directed "to procure a good bushel to be made and sized as above," and was to have "a seal whereby he shall seal that and all other measures," and "at the expiration of his office shall deliver the said measure and seal to his successor." 1641.

In Oct. 1654, during the first Assembly that was held under the Protectorate of Great Britain, the next act was passed relating to the Weights and Measures of the Colony. As it is expressed with a sort of stern brevity, quite worthy of the Protector himself, and strongly contrasting with the copiousness of phrase admitted both before and afterwards, I shall insert it in full from the existing document among the records of the Land-Office, as follows: 1654.

"It is enacted that there shall be a standard of Weights and Measures throughout this province; and that every County shall take the speediest course that may be for the providing of such standards, and be at the charge of them for their own County."

At April session, 1658, the first one immediately following the quasi-restoration of the province to Lord Baltimore under the Governor Fendall, (there had been but one session, 1658.

and that of short duration, intervening between this and the one just mentioned of 1654; for Cromwell in his heart does not seem to have been more fond of representative assemblies than the kingly Person whom he had dethroned) was passed an *Act concerning the guage of Tobacco-Hhds.;* by which it was provided that all such Hhds. "which shall hereafter be made in this province shall be of the size of 43 inches in length and 27 inches in the head and not under the size of 42 inches in length and 26 inches in the head." These continued to be the legal dimensions for upwards of thirty years.

1661. *An Act concerning the setting up of a Mint in the Province of Maryland,* which was passed three years after (in 1661) serves us to shew the recognition and use of the English money (then, Troy) weights in the Colony. It required, that the coin struck thereat should be of as good silver (there is no mention made of *gold*) as the English sterling money; and that every shilling so coined should weigh above nine pence of such silver, and other pieces in proportion.

And that the arts subordinate to Weights and Measures in this regard, had attained here a certain perfection, we learn from Folkes: who, in his Table of English Silver Coins, etc., mentions that "the Lord Baltimore, the Lord Proprietary of Maryland—coined there very handsome shillings, half-shillings and groats; all having his own head bare with the

legend CAECILIUS. DNS. TERRAE. MARIAE. etc. on the one side; and his arms under the crown of his palatinate, with the values XII., VI., or IV. and the motto CRESCITE. ET. MULTIPLICAMINI., on the reverse. It may be noted," he continues, "that all these American coins [he had been speaking just before of certain pieces coined in New England] want better than two pennies in the shilling of the weight of the English." He did not know that this was the intentional accuracy of the artist.

1671.

In 1671, was passed a new *Act for providing a Standard with English Weights and Measures in the several and respective Counties within this Province.* Its preamble recites, "that much fraud and deceite is practised—by false weights and measures;" and it then goes on to enact, that no one shall "make use of, in tradeing, any other weights or measures than are used and made according to the statute of Henry the Seventh." The statute here referred to, was that of 12 Henry VII, and dates in 1496; of which, in another part of this Report, more particular notice will have to be taken again. The Act then appoints one person, in each of the nine existing Counties, to "sett up a standard at their own houses and provide, by the next shipping or the shipping then next following at farthest, twelve half-hundred weights, a quarterne, half-quarterne, seven pounds, four pounds, two pounds, one pound. Alsoe each person above named are to procure six stamps for

the marking of stylyards and weights; the first six to be marked with the letter A. for St. Mary's County," and so on to the letter I., inclusive; and also "nine irons numbered from one to nine, and another with a cypher, for the numbering of stillyards and pea, that they might not be changed." We may conclude that the weights (as might be supposed from the establishment of a mint) were considered well authenticated; especially as, directly afterwards, the persons named were "to procure brass measures of ell and yard to be sealed in England; likewise a sealed bushell, half-bushell, peck and gallon of Winchester measure; gallon, potle, quart, pint and half-pint of wine measure; with three burnt stamps for the wooden measures, and three other stamps for the pewter measures, to be all of the same letter with their other stampes." The Act then goes on to say that the barrel is to contain five bushels; and it and the other measures and weights are to be brought once a year to the houses of the persons aforesaid in the respective Counties, to be tried and marked. A penalty of 1000 lb. of tobacco for every default is then imposed upon selling by other Weights and Measures than have been so tried and marked; steel-yards "carrying grosse weight," i. e. graduated by the long hundred, are positively interdicted; and a fee of two shillings for every steel-yard and of six-pence for every wooden and pewter measure tried, is allowed to the standard-keepers. The remain-

der of the Act provides for a levy of 1600 lb. of tobacco on each County, to pay for procuring the standards, with power to the Commissioners of the several Counties to audit the respective accounts and make an additional levy if necessary. In case of the death of any of the persons named, (their refusal to serve does not seem to have entered into the account) the Commissioners in the proper County were to appoint a successor.

The Act was in terms to continue for three years; but it was re-enacted or revived under other titles from time to time: so that it may be regarded as having remained substantially in force until 1715.

In 1676, there was had a sort of codification or, as the compiler, Bacon, terms it, a fixing of the laws to this period, upon the occasion of the demise of the Baron Cæcilius; his son and successor, Charles, who had for many years resided in the province as Governor, being now present and giving his voice as Proprietary. Among the results of this crisis, was the literal repeal of the act of 1658 relating to the guage of Tobacco-hhds., which has been before mentioned: but the substance of the act and the prescribed guage were still retained in a new *Act touching Coopers and guage of Tobacco Hhds.*, now added to the Laws. 1676.

In 1692, during the abeyance of the Proprietaryship and sequestration of the province to the crown of William & Mary, occurred 1692.

one of the modifications of the law of 1671, which were just now alluded to, in the passage of an *Act for the settling of a Standard with English Weights and Measures within the several and respective Counties of this province.* In this, the old Act, which had been omitted to be re-enacted the year before and had expired therefore by its own limitation, is referred to and revived as nearly as possible in phrase. The only substantial differences are in giving now to the Justices of the respective County Courts, instead of the County-commissioners, the power of appointing the standard-keepers; and in making it the duty of such Justices to replace all such standards as should be lost or impaired. A new County, Cœcil, had in the interval been erected; and a tenth set of Weights and Measures, to be marked in regular order with the letter K., were directed to be procured for that County.

In the same year, was passed a new *Act touching Coopers and the guage of Tobacco Hhds.;* which was limited to three years, but in fact lasted only two. It provided a new guage of 44 inches in length and 31 inches in the head, and not under 43 inches in length and 30 inches head; being an enlargement of 1 inch and 4 inches, in the two dimensions respectively, above the old dimensions. The coopers, who, from the way in which the law speaks of them, seem to have required a stimulus and a regulation as regards quantity, quality and finish of their work, are enjoined

to complete one-half part of all and every contract, that they or any of them may enter into, by the tenth day of October and the other half by the tenth day of December in any and every year; and all hhds. were to be made of stuff, the timber of which had been felled by the last of April, and which had been riven or got out by the last of July, and were not to weigh, empty, more than 90 pounds.

Little more than two years after, in Sep. 1694, was passed a new Act under the same title; by which of course the former became inoperative. By this, the hhds. were to be 48 inches long and 32 inches in the head, and not less than 46 and 31 inches respectively: the particulars of the late Act, as to contracts and the periods of their fulfilment and of the felling and riving of the stuff, are repeated here: but the fixed tare of 90 lb. per hhd. is dispensed with; and instead, the cooper is to mark the actual tare, together with the initials of his name, upon the bilge and to be allowed a margin of five pounds either way for an error in weighing, without being subject to the rather heavy penalty which the Act imposes. 1694.

In April 1700, the law of 1692, relating to the *settling of the Standards* was confirmed; and an additional Act to the one just mentioned *touching Coopers and the guage of Tobacco-Hhds.* was made. But this last Act is only a penal one against the planters, whom it charges with being the 1700.

"principal transgressors" of the law of 1694; and instructs the Grand-Juries to bring in indictments against all such offenders.

1704. Another Act *for ascertaining the guage of Tobacco Hhds.* which was intended to take the place of all the foregoing, was passed by the Assembly in 1704. By this, a penalty was imposed upon any one for using hhds. exceeding 48 inches in the length of the stave and 32 inches in the head, or less than 46 inches in the staves and 30 inches in the head; the true tare, within 5 lb. over or under, was to be marked upon the bilge; and finally, "for the better ascertaining what tare shall be allowed," the act says, "that the receiver of any hhd. of tobacco shall pay and allow to the owner or owners thereof, for each hhd. received, the sum of 40 lb. of tobacco; deducting the same out of the gross weight of each hhd. marked on the bilge, and no more." This last provision was equivalent to making the purchaser pay for about one half of the habitual tare of the hhds. But the dis-assent of Queen Anne, which was expressed in 1708, abrogated the whole law; and the subject returned to where it had been placed by the statute of 1694.

In the same year, 1704, the *Act relating to the Standard of English Weights and Measures*, recites that "there is now a standard of weights and measures, agreeable to the standard—in Her Majesty's Exchequer in England, settled with the several Coun-

ties of this province;" and goes on to enact that every person shall have his weights and measures tried yearly, allowing a fee to the standard-keeper of one shilling for each steel-yard (one half of the allowance in 1671 and 1692) and of sixpence apiece (the old fee) for the capacity-measures, "except they come out of England and are there stamped."

1708. At Dec. Session 1708, was passed the *Act for settling the rates of foreign silver Coins within this province.* This refers to the Queen's proclamation of 1704 and to the Act of Parliament of the year just previous (stat. 6 Anne) for "ascertaining the rates of foreign coins in Her Majesty's plantations;" and closes with a Table in which the mint-weight, intrinsic worth, and provincial current value of various Spanish, Portuguese, French, Flemish, and German coins are stated. This is of no farther interest to our present purpose than to show the identity of the Troy weights accepted in the province, with those of England; and that the proportion between currency and sterling (viz. as 3 to 4), which had been established by the Mint-law of 1661 and the Coins-act of 1686, was still recognized.

1711. The guage of Tobacco-hhds. was ascertained afresh in Oct. 1711, by an Act passed for the purpose; and which also comprehended certain penal provisions in regard to cutting and defacing tobacco taken on board vessels upon freight. Every one, after the tenth of October in the ensuing year, was

forbidden, under a forfeiture equivalent to the contents of a loosely packed hhd., from having any hhd. made larger than 48 inches in the stave and 30 inches diameter of head within the croze. As in the former Acts, the tare was to be marked upon the bilge; and an allowance of 5 lb. was made for error in tare in either sense, against forfeiture on the part of the cooper.

1715. In April 1715, the first year after the accession of George I, passed the *Act relating to the Standard of English Weights and Measures;* which continued in the Statute-book during the whole remaining period of our colonial existence, and was not indeed formally abrogated for a half century afterwards. The preamble to this is a testimony to the necessity of proper materials and modes of construction for objects which perform so important a function in a Commonwealth as such standards. The Act of 1704 had announced them as "settled," and therefore existing in good condition, in the several Counties: ten years later, this act declares that "standards—are very much impaired in several of the counties of this province; and in some, wholly lost or unfit for use." The remainder of the statute is very similar to the old one of 1692: the Justices of the County Courts, respectively, are directed under penalty, to complete and to procure anew where necessary the collection of standards as before prescribed, and "for the better preservation of them for the future, to take good and sufficient security" from the

persons with whom they shall be entrusted. The former provisions are then re-enacted, as to the annual trial of all weights and measures and the fees therefor; penalties for refusals and omissions are prescribed; and to guard against an undue captiousness, any one, who shall, by impeaching the accuracy of steel-yards duly proven and stamped, compel the owner to have them tried over within the year, is declared (as in 1671) liable to pay the cost of such trial if the measure in question shall prove to be correct.

1715.

The deterioration in the staple of Tobacco has been already indicated by the progressive increase in the capacity of the hhds.—the commercial unit of value of that article; till they had come to contain upwards of 50 per cent. more than had been the legal capacity in 1658. It is more distinctly averred, however, in an Act which also was passed this year, *ascertaining the Guage and Tare of Tobacco Hhds.*, and providing for several other matters not relevant to the present inquiry. This law, after alluding to the insufficiency of former Acts to secure observance, goes on to say that, the generality of the tobacco grown being so trashy and light, enough cannot be got in a hhd. of the late guage of 30 inches across the head (prescribed by the Act of 1711) to pay expenses; some having even been brought in debt by their shipment: and while it declares that nothing herein is to be construed as abrogating or repealing

the said Act of 1711, it yet legalizes as a maximum a length of 48 inches in the staves and a width of 32 inches in the head within the croze and a diameter at the bilge (this is the first time of specifying such a measurement) of 37 inches,—"thirty-six inches being supposed a competent guage." These dimensions give a capacity not very far from twice as great as that recognized fifty years before.

1716. This Act was to remain in force, only until the end of the session, which should happen next after 10 May 1716: and accordingly at the session of July 1716, a new one, in title and substance somewhat altered, *ascertaining the Guage of Tobacco Hhds.*, etc., was passed. But the terms of this, so far as relates to the guage, are a transcript of the former. The new enactment, rather than continuance, seems to have been more appropriate, inasmuch as in the interval, the Province had been restored to the Proprietary sovereignty.

1717. This last Act was to continue in force till 29 September, 1720; but in the following year, 1717, another new one, under the same title, retaining the same particulars as to guage, etc., and applying for the same period, took its place.

1730. By five successive renewals, this Act of 1717 was continued in force until 1730: in May of that year, an *Act for improving the Staple of Tobacco*, etc., whose aim was especially to restrain and regulate the growth and culture of the plant, con-

firmed the prescribed guage and some other particulars of the Act of 1717, and extended so much of its provisions till 29 Sept. 1732.

At July session 1732, these were all replaced by a new law *ascertaining the Guage and Tare of Tobacco Hhds.;* which however repeats verbatim the guage of 1715. And the same dimensions are retained in the Act of 1736; which by successive continuances was prolonged until 1 Dec. 1748, when it expired under the first general Tobacco-inspection Law of Maryland. 1732. 1736.

Up to this time, there had been no express assize of barrels or casks; except by the Acts of 1641 and 1671, which merely prescribed that the barrel for grain should contain five Winchester bushels. The subject was most likely supposed to be provided for in the last-named Act, recognizing all the units and combinations adopted by the English statute of 12 Henry VII; a statute which, by a singular fatality of error, would have legalized, had it been practically carried out, neither the Winchester bushel nor the habitual wine gallon of the Province. At any rate it was found necessary now, "for prevention of frauds and abuses frequently practised by greedy and avaricious traders," (as the record says) to prescribe in terms *the Guage of Barrels for pork, beef, pitch, tar, turpentine; and Tare of Barrels for flour or bread.* By this, all barrels in which any of the articles of the first mentioned class should be packed or filled 1745.

were to contain at least 31.5 gallons, wine measure; and the contents of pork or beef in such barrel "at exportation or sale, shall be, at the least, 220 lb." A penalty of 5 shillings currency, for every barrel, was imposed upon all persons who should, after 1 October 1746, pack flour or bread for sale and shall not mark on the bilge the true tare of said barrel or cask. This Act was continued by divers express renewals till 30 Oct. 1805; and subsequently, by several general reviving laws, till some years later. Not finding upon a moderately accurate research any traces of a specific mention, I conclude that it remains substantially in force, except as regards flour-barrels, until this day. The law of 1786, made with the same purview for the (then) town of Baltimore, and prescribing the dimensions of the staves and head, yields a guage in wine gallons almost exactly the same as given in this.

1747. In 1747, to take effect from 1 Dec. 1748, was made a further alteration in the guage of Tobacco-hhds., by a law then passed, whose comprehensive purport is that of an *Act for amending the Staple of Tobacco, for preventing fraud in His Majesty's Customs, and for the limitation of Officers' fees;* and which has been already referred to as the first of the Inspection-laws. By this act, the stave-length of 48 inches (prescribed by the act of 1736) was still retained; but there is no distinction made between the diameters at the head and bilge. The sum of these is taken at 70 inches;

the distribution of this sum is left unrestricted, on the correct supposition that any probable difference between two such diameters, to which the convenience or accidents of construction might lead, would not materially affect the capacity of the cask. It places an additional check, too, against error in this regard, by prescribing the nett weight of the hhd. when packed, to be 950 lbs.; and it directs farther that there be provided, in each of the Warehouses authorized by the act, "a sufficient beam, weights, and scales, to weigh 1200 gross lbs. at the least, and a set of small weights such as are or ought to be provided for the standards of each County."

1753.

The same guage is retained in the second Inspection-law under the same title, passed six years afterwards; but the nett weight of the hhd. packed, is in this omitted, though the prescription in regard to the weighing apparatus is retained. There were several continuances and supplements to this Law, each leaving these points as in the original; until they were all finally merged in the third Inspection-law of 1763.

1763.

This last Act, too, prescribes the guage in the same terms as in the former; it makes no provision as to the nett weight of the hhd. packed; but it raises the calibre of the scales up to 1500 lbs.; whence we may conclude that the tobacco was now being better packed. The requisition as to the small weights, is repeated; and the

County Justices are farther required, "sometime in the month of March in every year, to appoint two or more of their number to view the said scales, and examine and try the weights at the several Warehouses by the standard weights of the County;" in order to the necessary repair and that "the weights, if found deficient or differing from the lawful standard—may be made conformable." This Act, after divers continuances and supplements, expired on 1 Oct. 1771; but the dimensions it prescribed, continued to be the legal ones during a period succeeding, of sixty-five years.

1765. In 1765, a supplement was made to the Act of fifty years before, *relating to the Standard of English Weights and Measures*, in order to remedy a rather curious disorder. It recites that no penalty has been hitherto imposed upon *buyers* by dry measures other than such as have been tried and stamped at the standard; but that now "many buyers of grain, flax-seed and other commodities, when the people have carried them a great distance to market, refuse to buy them, unless by measure or measures of their own; which have been found on trial to be larger than the standard aforesaid:" and it therefore enacts, that buyers shall hereafter employ unstamped measures at their own peril, and under the penalty of £5 currency for every offence, if such measures shall be found larger than the standard. At least such is the construction that, in harmony with the

principles of the act of 1671, I place upon the terms of this; but if its intention was that no unstamped measure should be employed in any bargain and sale, with or without the consent of the bargainers, all that can be said is that the legislation then was both minute and comprehensive, and that the standard-keepers of that day enjoyed offices more lucrative than they do at the present. I have been thus diffuse upon this law, because it has never been specifically repealed; and unless it is held to be virtually annulled by the Act of 1825, it is yet in force.

1771.

The assize of barrels for Flour had not been hitherto regulated in terms; the Acts of 1641 and 1671, both, require barrels in general to contain five Winchester bushels; and that of 1745, which prescribed the contents in wine measure for certain barrels, in regard to flour only requires the tare of the barrel or cask to be distinctly marked upon its bilge. In 1771, however, the growth and commerce of Baltimore induced the passage of a law, presenting in its title a very comprehensive enumeration. It professes to be, in order *to prevent the exportation of flour, staves, and shingles, not merchantable, from the Town of Baltimore in Baltimore County; and to regulate the weight of hay and measure of grain, salt, flax-seed and fire-wood within the said Town,* etc. etc. By this, Flour-barrels are required to have staves of the length of 28 inches and headings of 18 inches; whose contents ($3\frac{1}{3}$ Win-

chester bushels) is about equal to the product, in flour, from five bushels of wheat. The other articles were to be weighed or measured, according to the County standard. This law was continued by several re-enactments and revivals, (though for the flour part it lasted only ten years, being then abrogated by another) until it was finally merged in the charter of Baltimore, in 1796. Although a local Act in terms, yet from its nature, it was intended to operate throughout the State.

1774. The same view is to be taken of another local act passed in Mar. 1774, by the last Assembly under the Proprietary government, *for regulating the guaging of Casks in the Town of Baltimore;* although it prescribes nothing as to the dimensions, except that the guaging shall be according to "the English standard and excise of wine measure." It was repeatedly renewed until the Baltimore City charter.

1781. In Nov. 1781, occurred the abrogation of the law of 1771 (as far as related to Flour barrels,) in the passage of an *Act to prevent the exportation of Bread and Flour, not merchantable; and for other purposes.* It contains a minute exposition of the number of hoops and nails which should go to the construction, "after the first of August next, of all flour-casks brought to Baltimore-town for exportation"—particulars which are not of interest to be detailed here: but it then prescribes "the following

dimensions, viz. the staves to be of the length of 27 inches, but of different diameter, at their heads, according to their numbers; that is to say:

Cask No. 1,	diam.	18.5	inches at the head;	to contain	224 lb.
No. 2,	"	17.5	"	"	196 "
No. 3,	"	16.5	"	"	168 "

Such were the provisions made by this Act. I have found no express continuance of the whole of it, beyond 1798; though some of its prescriptions are still habitually of force, as for instance the weight and dimensions of cask No. 2, which are those of the ordinary flour-barrel. As far as I am informed, the other two species of casks were never introduced into commerce; but the cask now marked No. 4, which is the common half-barrel, containing 98 lb., most likely grew into acceptation out of this law. The number, dimensions and weight of such a cask have never been specifically defined, that I know of; although the cask itself has been legalized by name, in more than one succeeding Act among those relating to the Inspection of Flour.

It may be remarked here, that the scale of weight adopted by this law, is not symmetrical with the dimensions; and we must either suppose that accuracy of calculation was neglected, or that the flour in the different classes of casks was intended to be of different specific weights, which may be produced either by different grades of bolting or different degrees of packing in the barrels. If the weight of a bushel of

water at 62° be called 100; the weight per bushel of flour in the casks, would be represented very nearly by the numbers 86, 84, and 81, respectively.

At this same session, occurred an important change in the currency; by the Act, declaring *what Foreign gold and silver Coin shall be deemed the current money of this State.* The old law of 1708, under a similar title, as well as the Coins-act of 1686, had given a current advance of $\frac{1}{3}$ above the intrinsic value; by which, for instance, the Spanish pillar-dollar, (that had been taken as a standard for European continental coin, and was intrinsically worth according to the then value of silver 4/6) was legalized at 6 shillings: the Act just doubled the current advance, and raised this same piece, the dollar, to 7/6. Estimating by weight, the intrinsic value of this was 61.714 pence per ounce, current in 1708 at 82.286 pence per ounce: it was now rated at 102 pence per ounce. The ratio of this advance was most likely not an arbitrary one; but had grown from circumstances, quite foreign to the affairs of the Province, and connected solely with the accidents of the Spanish coinage. The pillar dollar, which in 1708 was rated at 6 shillings, was the *old plate* (*plata antigua*, still known in Spanish numismatics as having been coined before 1686,) weighing 420 grains Troy; there was another dollar recognized in the same law as the *new plate* (*plata nueva*, coined since 1686) which weighed but 336 grains. In the lapse of a century, the old plate became more and

more rare; and was gradually replaced by the new; whose lightness of weight was not appreciable by every hand, and which came therefore to be accepted under the currency of the old, and to be worth 72 pence. Now 336 is to 72 pence, as 480 (grains in an ounce) is to 102 pence, very nearly. It was in this way that a current acceptation grew to be legalized. This Act was renewed at various times, till after the commencement of the present century; and, indeed, was not formally superseded until 1812.

1786.

I have already alluded to the Act of 1786, which is *for the Inspection of Salted Provisions*. By the old law of 1745, casks for such articles, were to contain 31.5 gallons, wine measure: by this, "all beef and pork barrels—imported into Baltimore-town from any part of the State" (which makes it more than a local law) are to have staves of the length of 29 inches, and be 18 inches diameter at the head. This is equivalent to a guage of 31.9 gallons, wine measure. Fish-barrels are to have staves 28 inches in length, and be 18 inches diameter at the head. The quantity of 220 lb. nett weight, prescribed by the old law, is continued in this.

1789.

In 1789, *an Act to regulate the Inspection of Tobacco*, required the standard-keepers of each County "to attend the Justices with the standard weights of the County, and assist in adjusting the beams and scales and trying the weights at the several Warehouses." There were many sup-

plements and continuances to this Act; but it, with all its dependencies, was finally repealed in 1801.

1796. In 1796, was passed the charter of the City of Baltimore; by which, among other things, the local power was given to the corporation "to establish and regulate inspections within the city, subject to the future Acts of the General Assembly; to regulate and fix the assize of bread; to provide for the safe-keeping and preservation of the Standard of Weight and Measure, fixed by Congress; and for the regulating thereby all weights and measures used within the City and precincts."

1801. In 1801, an *Act to regulate the Inspection of Tobacco*, repealed, as I have already said, the late Act of 1789 upon the same subject. It contains, however, the same provisions as that Act with regard to the standard-keepers, and prescribes for the hhds. the same dimensions as the Inspection-law of 1763. These dimensions continued till 1828.

1805. A supplement to the Baltimore charter, in 1805, refers to the powers before given to the corporation in relation to Weights and Measures; and enacts that "inasmuch as Congress have not yet fixed any Standard of Weight and Measure, and as much fraud and imposition may be practised from the want of such a standard," the Mayor and City Council shall regulate all weights and measures within the City and precincts "by the present standard, until one shall be determined on by Congress."

This question of the fixing of a Standard by Congress, was exciting a good deal of interest and attention about this time, and drew many Memorials on the subject from different parts of the Union. In 1809, Maryland took public part in it, by the passage of a resolution; instructing her Senators, and requesting her Representatives, "to use all proper means and exertions to procure the passing a law, establishing Weights and Measures." I do not find on the Journal of the U. S. Senate any notice of this resolution. 1809.

An Act of 1811, *to regulate the Inspection of Lumber*, requires that "all planks, boards, or scantling, not exceeding 8 inches square—shall be measured by the rule of board-measure, except boards under $\frac{3}{4}$ of an inch thick, which shall be measured on the surface;—all timber above 8 inches square, to be measured, if required by the seller; and all laths for plastering—shall be put up in bundles of 100, each, and shall be—not less than 4 feet in length—$\frac{3}{16}$ of an inch in thickness and—one inch wide." To this, there was a supplement in 1817; which does not alter the dimensions, and relates principally to the quality of the articles. 1811.

In 1812, all the regulations hitherto made in the Province or State, regarding the use of Troy weight for coins, were merged in the Act *recognizing the Coins of the United States, and the value of Foreign Coins as established—by Congress.* 1812.

1816. A new object of Inspection and measurement, came up in 1816; in the Act *to regulate the cording of Fire-wood in the City of Baltimore.* Although in title, it refers only to Baltimore, yet it is general in its application; requiring that "all fire-wood brought to Baltimore [and of course cut for sale, any where else in the State] shall be at least 4 feet in length, including one-half of the kerf; and not less than two inches diameter at the smaller end:—every cord shall be 8 feet in length, 4 feet in breadth, and 4 feet in height; and where the wood to be measured exceeds or falls short of 4 feet in length, the cord shall be proportionably increased or diminished." The provision, in regard to the diameter at the smaller end, has been dispensed with, subsequently.

1817. In 1817, *an Act to regulate the Inspection of Salted Fish*, modified the former law of 1786; leaving the length of the staves (as before) 28 inches, but reducing the diameter of the head between the chines, to 17 inches, and requiring the contents to be not less than 29 gallons, nor more than 31 gallons. The mean capacity would demand a clear diameter, at the bilge, of $18\frac{1}{8}$ inches. The tierces were to hold not less than 45 gallons; and the half-barrels not less than 15 gallons. The packing in kegs of less than 10 gallons, is expressly excluded from any operation of this Act.

A similar exclusion was made, by a supplement at the same session, in regard to fish put up at the Po-

tomac Fisheries for sale in ports of Virginia or the District; and in the following session, a further modification of the original Act was made, in allowing Fish-barrels to be "passed, in case they are of the following dimensions, viz: the staves 28 inches in length, and a half inch thick; the diameter, at the cut head, shall be $17\frac{5}{8}$ inches; the chines shall be $1\frac{1}{8}$ inch in depth; and the bilge of each and every barrel shall be not less than 20 inches in diameter." These dimensions appear to have been arrived at with more than usual accuracy: they give, almost exactly, a capacity of 31 wine gallons. 1818.

The Act of 1823, *to establish State Warehouses for the Inspection of Tobacco in the City of Baltimore*, has no farther connection with Weights and Measures than that, by sec. 9, the inspectors are directed to provide "weights and scales to weigh 1500 gross lb. at the least, and a set of small weights such as are provided for the standard Weights of said City." 1823.

In 1825, passed the *Act for regulating and inspecting Weights and Measures used in this State*, hitherto under the domain of the old Act of 1715. This new law enacts 1825.

1°. That the Governor and Council, on or before 1 Aug. 1826, should furnish the Levy Court of each County with a standard of each of the several kinds of Weights and Measures used at the Custom-house in Baltimore.

2°. That the Levy Court, on or before 1 May in every year, should appoint a keeper of the standards as furnished; taking a bond in the penalty of 500 dollars for malfeasance or damage to the standards.

3°. That the standard-keepers shall once a year inspect, and stamp or brand with the letters M. S. (*Maryland Standard*) in the most effectual manner, all weights and measures used in the vending of articles within this State: the employment of Weights and Measures otherwise, shall be under a penalty not exceeding 20 dollars.

4°. That a penalty of the same amount be imposed upon the employment of weights and measures once stamped or branded, but now degraded or condemned.

5°. That all scale beams shall be inspected and stamped, as aforesaid; under like penalty.

6°. That the keepers of the standards attend, at least once a year, at the different markets, towns and villages of their County; and at the public inspection Warehouses, at least twice a year; after giving public notice: they shall inspect and adjust all beams, weights, and measures, and shall enter such adjustment in a register, with the names of the parties, to be submitted to the Levy Court.

7°. That a penalty of 5 dollars be imposed upon all and every person or persons, for each day they shall neglect or refuse to have their weights and measures inspected, after having been required by the

standard-keeper: and, in case the keepers have reason to suspect that such neglect proceeds from a fraudulent intent, they be authorized to examine; and, if the suspected articles should prove defective, to seize upon, adjust, and sell them for the use of the County.

8°. That annual statements be returned by the keepers to the Levy Courts respectively, of the amount of money received.

9°. That the compensation of the keepers be as their Levy Courts shall allow; to be levied for as other County-charges.

10°. That when the keepers are applied to, to alter any beam, weight or measure, so as to make it correct, they shall be allowed an additional reasonable compensation; to be paid by the applicant.

11°. That one half of all fines and forfeitures under this Act, shall go to the use of the County; the other half to the informer, who shall be a competent witness of fact.

12°. That the Treasurer for the Western Shore pay any sum necessary to carry out this Act; which, however,

13°. Is excluded from operation upon private persons not in trade, or at all upon the City of Baltimore; provided the Baltimore ordinances make their standards uniform with the rest of the State.

It does not particularly interest our present inquiry, but it is worthy of remark that this new law

makes no provision as to the fees which shall be paid for adjusting standards: it is presumable, therefore, that the intention was to leave this point where it had been placed by the act of 1715. We shall find, after this date, some supplements by which a special regulation in this particular is made for a few of the Counties.

1827. Two years afterwards, was passed the *Act to regulate the Guaging of Casks and the Inspection of domestic Distilled Liquors in this State.* It prescribes, among other things, that the guagers to be appointed under it, "shall conform to the present Baltimore standard of wine measure," using correct guaging instruments and Dycus' hydrometer, 85 degrees of which is the standard of proof-spirit: but whenever the government of the United States shall determine to employ a different hydrometer, the State-guagers shall procure and use hydrometers of the same description. I believe, that the one mentioned still continues to be employed.

1828. Up to 1828, the legal dimensions of Tobacco-hhds. (though the actual ones had varied,) had remained the same that were fixed in 1747. By a law of Dec. session of this year, to take effect on and after 1 Dec. 1829, increased dimensions were authorized, viz: "not exceeding 50 inches in the length of the staves and 76 inches in the whole diameters within the staves, at the croze and bilge." As this is the last law regulating the

size of these hhds., I shall present in one view here, the changes which have been made, and when, in that particular; from the first time of its being the subject of a statute. The numbers in the column headed "proportionate capacity," happen to be about $1\frac{4}{10}$ per cent. below the respective actual contents in wine gallons.

Table shewing the legal Dimensions and proportionate Capacity for Tobacco-Hhds. at the several epochs below.

Date.	Stave-length. Max.	Min.	Head-diam. Max.	Min.	Bilge Diam.	Sum of Diam. Head & Bilge.	Proport. Capacity.	Remarks.
	in.	in.	in.	in.	in.	in.		
1658.	43	42	27	26	.	.	100	
1692.	44	43	31	30	.	.	136	hhd. to weigh 90lb.
1694.	48	46	32	31	.	.	156	tare to be marked.
1704.	48	46	32	30	.	.	161	tare to be rated by purch'r at 40lb tob.
1711.	48	.	30	.	.	.	145	tare to be marked.
1715.	48	.	32	.	37	.	201	not to repeal prec'dg.
1747.	48	.	.	.	.	70	204	nett wt. in hhd. 950lb
1828.	50	.	.	.	.	76	250.	

In 1829, a new subject for the operation of Weights and Measures was introduced by an Act, local in its title but, I presume, applicable to the whole State in effect, *to provide for the Inspection of Shingles at Port Deposit.* By this a "bunch of shingles 3 feet 4 inches between the bands, with 50 courses upon each side, and closely packed, shall be considered to contain 1000 shingles; and bunches, whose dimensions and contents shall not be equal thereto, shall be estimated and marked accordingly, that is to say $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ or $\frac{7}{8}$, as the same may contain." 1829.

In the same year, was made a special Act *to provide for the counting of Staves and Heading in this State;* by which the count was to be by the just, or as the Act calls it, the short hundred; "so that 1000 pieces shall be computed as M. staves or headings:—and any inspector or dealer—attempting to count—at the rate of 1200 to the M., or at any greater rate, shall upon conviction be fined not exceeding 100 dollars." The method contemplated by this law is undoubtedly a correct one, but hereafter in this Report, we shall recognize for the long hundred here interdicted, an antiquity far out-dating the discovery of this Continent.

The same principle of just count was affirmed in another Act of this same year, supplemental to a former one (of 1818, not hitherto quoted because it has no connection with Weights and Measures) *respecting Hay and Straw brought for sale to the City of Baltimore;* by which the weighers are directed "to make out their certificates for every 100 lb. weight, instead of 112 lb. as they now do; and every 2,000 lb. nett weight shall be considered a ton, and so in proportion." The method to be applied to these articles, seems to have been a topic of more than usual interest, or more than usual difficulty; for this enactment has been repeated almost literally four times since: once, in 1832, applying to the whole State; then, in 1836, upon the proposed erection of City-scales: again, in 1837, upon their conversion to State-scales;

and then, in 1839, supplemental to the establishment of State-scales in the City of Baltimore.

And the same principle was carried out, two years afterwards, and applied generally to all articles, by the law *to regulate the weight of Quercitron*, etc.; by which it was enacted, that thereafter with "all Quercitron and all other ground bark, sumach, and all other articles sold by weight in this State, 100 lb. shall be taken and considered as one Cwt.; and that 20 hundred be considered and taken for one Ton, and so in proportion—any law to the contrary notwithstanding." This act, as published, is more noticeable for its brevity than for its concision or literary accuracy. 1831.

An Act of the same year, *for the Inspection of Sole Leather* in Baltimore, would not be referred to here; except for the provision in it, that the Inspector "provide himself with such and so many scales, weights, and stamps, as may be required." It comes therefore within the purview of Weights and Measures.

In the same year, a supplement to the Act of 1825 *for regulating Weights and Measures*, transferred the standards of Harford County to the office of the Commissioners of said County; and the Clerk of the Commissioners, or some one else to be appointed by them, was constituted keeper of the standards. The Act farther allows, what the original Act did not do in terms, as I before observed—a specific compensation for each comparison made.

1832. In the following year, by a second supplement, a like change was made in regard to the standards for Allegany County; and a peculiar clause was introduced by which the standard-keeper, appointed by the Commissioners for said County, is to perform all the duties that are required by the original Act, "or so much thereof as the said Commissioners may, in their discretion, deem necessary." The fee for comparisons with the standard, is made the same as for Harford County: the compensation to the keeper, is to be such as the said Commissioners "may think fit and reasonable."

In this same year, the appointment of two persons as Lime-inspectors for the City of Baltimore, was vested in the Mayor and City Councils of said city; (this power was afterwards, by an Act of 1835, revoked and given to the Governor and Council) and it is made the duty of the persons so appointed to measure "all lime brought to the City of Baltimore, or to be used therein—by the standard bushel or Baltimore seal, in which is contained 2150 cubic inches."

A kindred article, Gypsum or Plaster of Paris, was likewise in the same year, by another Act, brought under inspection in the same city: but the duty of the Inspector is confined to the weighing of all such plaster, as shall be offered for sale in barrels; "which barrels shall be of the size of the common flour barrel—and shall not contain less than 320 lb. nett weight."

But in the following year, a supplement to this last Act took off the obligation to offer Plaster of Paris in casks of any definite size; the Inspector's fee is however still rated, in accordance with so much of the original Act, by every 320 lb. nett. I may remark in passing, that lump or stone plaster is exempt from any penalty in being offered for sale uninspected. 1833.

But in this same year, a local Act, applying to the same article in the Town of Bladensburg, repeats, as far as Weights and Measures are concerned, the terms of the original Act for Baltimore.

At the session of 1834, a third supplement to the Act of 1825, *regulating Weights and Measures*, applied to Anne Arundel County in terms what had been, by the first supplement, enacted in regard to Harford County. I believe that, in point of fact, no substantial change was contemplated by either of these supplements: they were only to satisfy a formal necessity. The original Act expressly made the Levy Courts of the several Counties, the depositories of the standards: now, these three Counties at least (I do not know if any, or how many, others) had no Levy Court by name—the functions of that Institution having been transferred to a body termed the Commissioners of the County. I presume it was only to remedy the apparent non-conformity, in the Counties mentioned, to the Act of 1825, that the supplements were desirable. 1834.

1836. In 1836, although hitherto the material of which any measure, and especially a measure of length, should be made, had not been the subject of legal prescription, a local Act for the Town of Williamsport seems to have been considered requisite; by which "the Inspector of Lumber shall be permitted to measure all lumber with a tape-line, having thereon legibly marked its length, in feet and inches." This Act comprehends various other provisions: it is to be presumed that the one I have indicated, was not the inducing aim of its enactment.

Another Act of this year, respecting Hay and Straw, I have already alluded to, as requiring the computation of 2,000 lb. to the ton; but I did not mention that the weighing-apparatus was required to be inspected and adjusted, at least once in six months.

This adoption of the short Ton, which, by the Quercitron-act formerly mentioned, had been in terms applied to all articles sold by weight, was modified by another Act of the same session (1836) in regard to *the Inspection of Anthracite and bituminous Coal.* By this Act, all anthracite was to be sold by the ton; "and 2240 lb. of any Coal shall be allowed to the ton." Bituminous Coal was to be measured "in measures—to contain the quantity of 3 bushels of bituminous Coal." The phraseology of this Act was not remarkably distinct; but the substance of it, (it authorized the Executive appointment of two officers, by whom all anthracite sold must be inspected and

weighed; and all bituminous coal sold in parcels larger than 3 bushels must be measured; and thus in fact it increased the price to the consumer by 12½ cents per ton, and a half-cent per bushel, respectively) it is presumed, chiefly led to its repeal, which took place at the next session of 1837. The Act repealing it, takes away all inspection except as to the weights and measures employed; the former of which must be proved at least twice a year: in case of difference between buyer and seller, the standard-keeper in each City and County respectively, is to be the umpire. The long ton of 2240 lb. is retained for anthracite; "but all bituminous Coal, hereafter sold in the State of Maryland, shall be sold by measure—proved and stamped by the proper officers of the City, or County, where the same is to be used; except foreign Coal subject to duty, in which case the measure of the General Government will be used." The Act does not, in this place, state what denomination of measure shall be used; but as, in a subsequent section, the fee of the standard-keeper who may be called in between buyer and seller, is rated by the bushel, no doubt such was the unit contemplated by the law. The exception with regard to foreign coal is at least unnecessary; for it is to be presumed that an authenticated measure of the General Government would, in any case of difference, take legal rank above any copy of a City or County Standard, or even above such very standards themselves.

1837.

1837. 1839. The Acts of 1837 and 1839, in regard to the Ton for *Hay and Straw*, have been already mentioned.

1841. In 1841, an Act, for the first time, regulated *the Inspection of Red-oak Staves and Headings in this State;* by which "every sound stave 28 inches long, 3 inches wide, $\frac{5}{8}$ of an inch thick on the heart, and clear of a bad knot, shall be—counted as a prime stave; and every sound heading, 18 inches long, 5 inches wide, and $\frac{5}{8}$ of an inch thick on the heart, and clear of a bad knot, shall be—counted as a prime heading." All other staves and heading, not coming up to this standard, are to be thrown by, as cullings. In the next year, a supplement to this, applied its terms to White-oak staves and heading.

1842. I should not mention a local Act of this session, though substantially universal in its application,—*to regulate the Inspection of Lumber for the City and County of Baltimore*,—were it not for an amendment which it introduces into the terms of the old law of 1811. That law applied the rule of board-measure to all Lumber, except "boards under $\frac{3}{4}$ of an inch thick, which shall be measured on the surface:" this Act makes the exception for "boards of an inch and under," which are to be by superficial measurement.

A resolution of the same session, is as follows:

"Resolved by the General Assembly of Maryland, that the Governor be and he is hereby autho-

rized and directed to distribute to the Levy Courts or Commissioners, as the case may be, of the several Counties of this State, each, one Standard of the several kinds of Weights and Measures which shall be received by this State from the United States." It is in accordance with this resolution, that the Standards of the present Establishment are being constructed.

Such are the principal Acts, making up the legislation of Maryland upon the subject of Weights and Measures; and I shall farther, in this regard, only present in one view a reference to all the Acts connected with the matter, which a tolerably careful examination, much more minute than the indexes accompanying the Statutes, has brought to my notice. In order that such a view may be of the greatest practical use and (as may happen) of aid in some other research, I have classified the Acts according to the different kinds and employments of measures, which they contemplate respectively. The order of sequence within that classification, is chronological.

I have not thought it necessary to make any distinction between Acts existing and those repealed or expired. In the historical aspect, where lay the chief interest for my purpose, and in which I have regarded them, the repeal is of equal importance with the passage of a law,—both being indications of the state of society or the condition of commerce, that moved or justified them; while to have made the

ascertainment accurately and throughout, would have imposed upon me a labor, tedious in performance and, when performed, without the sanction that a professional character in the Investigator alone could stamp. Nor have I made any distinction between general and local Acts; as e. g. regulations expressly for the City of Baltimore, Frederick, Williamsport, etc.: because such local acts were applied at the moment when there was supposed to be occasion for them, but they all either led to, or were, the developement of a general principle. Hence it is frequently to be found, that a particular application of Weights and Measures to Inspections of various kinds, (and it may be even be said, whether that inspection regarded quantity or quality, so that the phrase might have been, that a *particular system of Inspection*) has been made first at one point, as, for instance, Baltimore City; and then, when the commerce in the same article required it to be inspected at some other place, as, for instance, Frederick, the application was made by a law, saying, that the Inspector at such other place should be governed by the same rules as laid down for similar officers in Baltimore. Cases of this kind, I have not thought it necessary to note; but I have inserted all such laws as, first applied in any Town or County, have been afterwards extended in terms to *the State at large*, in order to mark the epoch of the practice; that of the principle, occurs at the passage of the very first law.

Classification and Dates of Laws of Maryland concerning Weights and Measures.

1°. Units of Weight and Measure.

1638, ch. xxxiv. 1641, ch. ii. 1654, ch. xxiv.
1671, ch. viii. 1678, ch. xv. xvi.
1681, ch. xi. 1682, ch. xii. 1684, ch. vi.
1688, ch. ii. 1692, ch. xliii. 1700, ch. viii.
1704, ch. lxxi. 1715, ch. x. xlix.
1719, ch. xvi. 1765, ch. i. 1796, ch. lxviii.
1805, ch. cviii. 1809, res. No. 4.
1825, ch. ccvi. 1831, ch. cliv. 1832, ch. ci.
1834, ch. clxxviii. 1842, res. No. 54.

2°. Measures of Length.

Long Measure.

1638 ch. xxxiv. 1671 ch. viii.

Staves and Heading: 1658, ch. ii. and sequence under No. 5.
1745, ch. xv. do. do. No. 4.
1771, ch. xx. do. do. No. 5.
1781, ch. xii. do. Nos. 4 and 5.
1786, ch. xvii. do. do. No. 3.
1817, ch. cxiv. do. do. No. 4.
1829, ch. cli. 1841, ch. cxc.
1842, ch. cxxvi.

Laths: . . . 1811, ch. lxx.

Superficial Measure.

Lumber: . . 1811, ch. lxx. 1817, ch. cxli.
1828, ch. cxxxi. 1836, ch. ccxxii.
1842, ch. cclviii.

Land Measure.

Not provided for otherwise than indirectly by
1671, ch. viii.

Solid Measure.

Fire-wood: . 1816, ch. cxcix.
Shingles: . . 1829, ch. cxlix.
Tan-bark: . . 1833, ch. cxxxiv.

3°. Measures of Weight.

Mint and Bullion: 1661, ch. iv. 1662, ch. viii. 1663, ch. xxxiv. 1669, ch. x. 1676, ch. ii.

Coins: . . . 1686, ch. iv. 1688, ch. ii. 1692, ch. xliv. 1694, ch. xvii. 1699, ch. xlvi. 1700, ch. viii. 1708, ch. iv. 1729, ch. ii. xv. 1781, ch. xvi. 1783, ch. xxx. 1784, ch. xxxiii. lxxxiv. 1786, ch. xxxv. 1789, ch. liv. 1796, ch. lxiv. 1798, ch. lxxi. 1805, ch. cix. 1812, ch. cxxxv.

Tobacco and Tobacco Hogsheads: . . . 1692, ch. lxxxii. 1747, ch. i. and sequence under No. 5. 1838, ch. lxiv.

Salted Provisions: 1745, ch. xv. and sequence under No. 4. 1786, ch. xvii.

Hay and Straw: 1771, ch. xx. and sequence under No. 5. 1818, ch. cxxv. 1829, ch. clxiv. 1832, ch. cxx. 1836, ch. ccxxxviii. 1837, ch. cccxix. 1839, ch. lvii.

Flour: . . . 1781, ch. xii. and sequence under No. 5. 1825, ch. clxxiv.

Fish: 1786, ch. xvii. 1817, ch. cxiv.

Ground Bark: 1821, ch. lxxvii. 1831, ch. ccxxxix.

Leather: . . 1831, ch. ciii. 1837, ch. xci.

Plaster of Paris: 1832, ch. cclxxxii. 1833, ch. xx. cclxxv.

Anthracite: . 1836, ch. cclxv. 1837, ch. cccxvi.

Live Stock: . 1837, ch. cccxiii.

4°. Measures of Liquid Capacity.

1671, ch. viii.

Barrels for brine, pitch, tar, turpentine, &c.: 1745, ch. xv. 1750, ch. x. 1753, ch. iii. 1757, ch. vi. 1760, ch. xi. 1763, ch. xii. 1766, ch. iv. 1773, ch. xv. 1781, ch. xxix. 1788, ch. xviii. 1795, ch. lxxxiii. 1798, ch. lxxi. 1805, ch. cix.

Liquor Casks: 1774, ch. xxiii. 1777, ch. xvii. 1784, ch. lxxxiii. 1785, ch. lxxvii. 1792, ch. lxxvii. 1796, ch. lxviii. 1827, ch. clxxxi.

Fish Barrels: . 1817, ch. cxiv. clxx. 1818, ch. xcix.

5°. Measures of Dry Capacity.

Grain: . . . 1638, ch. xxxiv. 1641, ch. ii. 1671, ch. viii. 1765, ch. i.

Tobacco Hogsheads: . . . 1658, ch. ii. 1663, ch. xxxiv. 1676, ch. ii. ix. 1692, ch. lxxxii. 1694, ch. v. 1700, ch. iv. viii. 1704, ch. liii. 1711, ch. v. 1715, ch. xxxviii. 1716, ch. viii. 1717, ch. vii. 1720, ch. ix. 1721, ch. iii. 1723, ch. ii. 1726, ch. iv. 1729, ch. v. 1730, ch. vii. 1732, ch. xxv. 1736, ch. ix. 1740, ch. x. 1744, ch. vii. 1747, ch. i. xxvi. 1753, ch. xxii. 1763, ch. xviii. 1765, ch. xxix. 1766, ch. i. xix. 1769, ch. vii. 1770, ch. i. 1789, xxvi. 1801, ch. lxiii. 1828, ch. clxiv.

Flour Barrels: 1771, ch. xx. 1778, ch. xv. 1780, ch. xxxvi. 1781, ch. xii. 1787, ch. xxxviii. 1795, ch. lxxxiii. 1796, ch. lxviii. 1797, ch. cxvi. 1798, ch. x. 1801, ch. cii. 1803, ch. lxxxiii.

Lime: . . . 1832, ch. cclxix.

Bituminous Coal: 1836, ch. cclxv. 1837, ch. cccxvi.

With these particulars, I shall conclude here the first Part of this Report.

PART II.

OF THE AUTHENTICITY, VALUES AND RELATIONS OF THE SEVERAL UNITS OF THE PRESENT SYSTEM.

The standards of the present Establishment come to us from the Treasury Department of the United States' government; and it is therefore to some Instruction from the same source, that we should look for a full elucidation of the points which form the caption above. But in the absence of such a document, and especially as nominally these standards have been accepted here in Maryland by all our legislation, provincial and sovereign, a long time anterior to their existence under the present mode, it is necessary now, in order to illustrate what has been exposed in the preceding section and thus to shew what the laws themselves actually had in view, that we should refer to the common originals of our old standards and our new.

Both of these come from Great Britain; and the history of their variations in that country might be, for our present end, strictly limited between the epochs of their co-temporaneous introduction here,—

that is, to a period of about 200 years. But as some of these variations, without notice of earlier organizations and disorganizations, would appear capricious or unaccountable, I shall be excused, I hope, in devoting a few moments to the aim of rendering these more intelligible.

For this purpose, I shall not ascend to those remote times when the footsteps of man begin to lose themselves in the forest of antiquity; I shall not enquire into the primitive origin of all Weights and Measures, nor examine if the type of ours was cut in a Saracenic, Roman, Greek, or more oriental still, Egyptian font—all of which hypotheses have agitated the learned: I excused myself, in the outset, from such discussions. I shall trace the matter no farther, then, than to the first semi-civilized or (as it may be called, under another aspect,) *classical* occupation of Britain.

Exactly nineteen hundred years ago, the Romans made their first entry upon that island. They carried with them at that moment, indeed, only the weapons of war; but a long provincialism, through nearly five centuries, nourished afterwards the arts of peace. The walls of Antonine and Severus, whose traces still remain, and whose name at least will be perpetuated as long as the northern English coal-mines last, attest with what zeal protection was extended to citizens, some of whom had emigrated from Rome itself; and the number of Roman coins, dug up continually

at many of the old legionary stations, show the great degree to which, soon after the invasion, money and its dependent system of weights and measures had been introduced to, and accepted by, the Celtic aborigines.

This acceptation was so generally expanded, as to have influenced the ratio of combination and, in a degree, the nomenclature of the English system of measures to this day. For instance, the Roman foot contained, according to the various remaining proofs of its length, from 11.604 to 11.846 English inches; and the Roman *uncia* or inch (of which, as with us, twelve made the foot) was thence 0.9670 to 0.9855 of our inch. In the application of linear to itinerary measures, it is from them that we borrow the proportion of 5 feet to constitute a *pace*—the length of a double step, or from foot-print to foot-print on the same side; and as with them 8 *stadia*, so with us 8 *furlongs*, make a mile. So in agrarian measures, the Roman *actus*, which lineally was (says Pliny) as far as ploughing "oxen are driven in one straight furrow" and thus corresponds in terms with the English furlong (literally, one *furrow-long*) became, when squared, their unitary acre,—equal in content to nearly one and a quarter English roods. It is true that their *jugerum*, which we undertake to translate as *acre*, contained two such square *actus;* but the term implied a yoke of oxen, and the thing was as much as two oxen could, on an average, plough in a

day: so that in fact, the actus or rood may be regarded, as I have said, to be their true unitary acre—the equivalent of the day's labor of an ox. And just as their habitual acre was an oblong, one of whose sides was the length of a furrow, our acre at this day is an oblong too, and one side a furlong.

Farther, the Romans made the distinction between their nummulary and their commercial, or, in their own terms, the *scale* and the *metrical* pounds; and we have now a Troy and an Avoirdupois—our mint and our market weight. The index, if not the unit, of this system of weights and of capacity-measures connected with them, was in Italy the weight of the silver denarius at 84 to the pound; and the similar unit was in England, thirteen centuries later, the weight of the penny sterling, the $\frac{1}{240}$ part of the silver pound. It was upon the multiplication of the money weight, that the system of capacity-measures depended. The measurement and adjustment of volumes being exceedingly difficult, and the mechanical construction of a perfect cube or a perfect cylinder being, even now, next to impossible, the Romans (as the Greeks had found necessary to do before them), regulated the size of these measures by the equivalent weight of their contents in those articles—wine and wheat—which formed the staples of their trade. The Greek equivalents were oil and wheat.

The unit of the Roman liquid capacity-measures, the *congius*, was understood by the Silian rescript or

plebiscitum, two hundred years before the invasion of Britain, to be such a vessel as would contain 10 nummulary or mint pounds of wine; and its size was recognized, not long afterwards, to be the eighth part of a cubic foot. It is from the weight of a remaining congius yet preserved at Rome, and undoubtedly of great antiquity (though hardly, as its inscription claims for it, a standard of the Emperor Vespasian, by whose name it is generally known) that the longest estimate of the Roman foot in English inches, which I gave just now, has been derived; upon the assumption, that the wine would be of the same specific gravity as distilled water, and upon the most recent determinations of the weight of the last-named liquid. Should we take, what is most proper, the weight of the wine to have been less than that of the water, and assign to it the mean specific gravity of the European lighter wines, equivalent to (say) 250 Troy grains per cubic inch, this congius of Vespasian, assumed to be perfectly authentic and accurate, would accuse a length for the Roman foot of 11.885 English inches.

On the other hand, the unit of the English liquid capacity-measures was likewise a vessel containing 8 commercial or market pounds of *wine*, (although England never was a vine-growing country as Italy and Gaul were, and wine was an article of commerce only by import); and its actual size may be inferred, from other proofs, to have been at that time also the eighth part of a cubic foot. The difference in the recital of

the weights in the two cases, 10 pounds in the one and 8 pounds in the other, in fact establishes the identity of their proportions (not dimensions) and the origin of the latter. The Roman congius was to contain 10 mint pounds of 12 ounces, or 120 ounces; the English gallon was to contain 8 market pounds of 15 ounces, or 120 ounces too: the ounce being, in the respective nummulary and commercial accounts, the same with each.

From these liquid measures, the transition was made proportionately, as it is with ūs, to the measure of things dry. But on this point, as the Roman writers have not been perfectly explicit, and the English not entirely clear, I may be allowed to enter somewhat upon the details involving the question of the relative values of the commercial and the mint pound; whose distinction, had it been treated of in connection with weights proper, could not have been so well understood as now. This exposition will besides help, when I come to speak of the early English system.

The Silian rescript before-mentioned, (it was in fact a proposition emanating from two tribunes of that family and accepted in a popular meeting, which sort of laws were termed *plebiscita*,) after saying that the quadrantal should be of 80 pounds (*pondo*) of wine and the congius 10 pounds (*pondo*) of wine, goes on to say: that the quadrantal should be 48 sextarii; that the sextarius [of wine] should be equal with the sextarius of dry-measure (æquus cum aridorum sextario);

and that the *modius*, which was the unit of dry measures should be sixteen pounds (*librœ.*)

The use of these two terms for weight, show that they did not both signify the same thing; and the etymology of the terms themselves, even without the collateral testimony by which it is supported, points to the proper application of each. The first (*pondo*) means, originally and simply, *weight*; it was the metallic weight, which, from its permanence and portability, would be very early employed, and especially in the case of counterpoising metal out of which money was to be made. It was therefore both the money weight and, in fact, money itself. But *libra*, which originally signified the implement used in counterpoising, (peculiarly, among the Romans, an apparatus like our steel-yard; and when the suspension was made in the middle of the bar, so as to require two dishes of equal weight, thence called specifically a *balance*, in Latin *bilanx*) when employed to denote a weight, signified the unit of weight employed for demotic and commercial purposes—the *metrical* weight, as Galen calls it; by which, account would be taken of the respective measures of equiponderant quantities of the two most important staples of their commerce.*

In accordance with these inferences, the Silian law

* It is true that at a later period, this name *libra* came to be applied to the money-pound of 12 oz.; the other, *pondo*, went into disuse; and the word *mina* was employed to express the commercial pound: but as the object here is to expose the principles, not the details of the system, it will be proper to continue the nomenclature accepted in the law. This note will be sufficient to warn the classical reader against any mistake.

establishes for wine, one of those staples, the equivalent of a certain measure of it in money pounds; and for the other, wheat, a definite weight in market pounds. According to the mode of its translation, it helps us to determine the accepted proportions of these two pounds, respectively.

The rescript says, in terms, that the *sextarius* (a measure very nearly our pint) of wine should be equal with the sextarius of dry things. Now this equality may be affirmed in either of three constructions: 1°. the two objects may be identical in *size;* or 2°. they may be identical in *weight;* or 3°. they may be proportionately equal, in *weight and size* combined.

The first of these constructions, is that which has most usually been understood by the English writers on this subject; it is that taken by Arbuthnot, for instance, the convenience and ingenuity of whose tables have procured for his estimates a currency, which the Dissertations, appended in editions after the first, would hardly have obtained. There are plausible reasons for its having been adopted; viz. 1°. the dimensions of this fractional part of the unit are immaterial to the system, inasmuch as the unit itself is determined by its weight; and whether the sextarius was absolutely large or small, the ultimate equation would be had, by making a smaller or larger number to constitute the unit: and 2°. its dimensions would be immaterial in practice, inasmuch as articles sold by the bushel, are rarely if ever reckoned by the

quart, and still less likely to have been reckoned by the pint, which was about the actual size of the sextarius in question. Now we know from accidental authorities, not so old to be sure as the Silian law, but not a great deal younger, that an equation as above mentioned was in fact obtained; for counted by measure, the modius, which was to weigh 16 libræ, contained 16 sextaries; a number that is not aliquot with any integral multiple of the sextaries in wine measure. To make it thus aliquot, it would have to be reduced in the proportion of 16 to 12, or of 4 to 3, which is not far from the relative specific gravities of wine and wheat in the growth of Italy. This, therefore, gives us the value of the *libra*, or wheat-pound, compared with the money-pound, as 16 to 12; and the ounces being taken as the same in both, while the money pound contained 12 ounces, the commercial pound contained 16 ounces. This 16-ounce pound we know, from numerous testimonies, to have been current under the Roman republic, as it had been earlier in Attica, and earlier still in Egypt: and a similarly divided weight is current with us to this day, under the name of the avoirdupois pound. Farther, 16 libræ of 16 ounces each make up 256 ounces; and 256.5 ounces are precisely the mean of the weights of a modius of Egyptian and Greek wheat, in the time of Pliny the Elder.

The second possible construction is that the liquid and dry sextaries should be identical in *weight*. In

this regard, both the name of the thing and the rescript of the Silii imply that the liquid sextarius weighed the sixth part of 10 money pounds, *i. e.* $1\frac{2}{3}$ pounds, equivalent to 20 ounces; and hence the dry sextarius, and its equiponderant the libra, must weigh 20 ounces too. It may be remarked that this also is not far from a recognized wheat-weight: for the modius, under this construction, would contain 320 ounces; and the wheat of Clusium, in Etruria, is stated by Pliny in his time to give 312 ounces to the modius. Nor is this 20-ounce pound unmentioned by ancient authorities. One of them, Epiphanius of Salamis (who wrote in the fourth century of our era, but whose writings contain quotations of a much older date) expressly calls it *mina Italica*—the Italian pound. It is true that an older writer, the physician Dioscorides, bestows this name upon a pound which he says is of 18 oùnces; and in so far agrees with the weight that Pliny gives for the wheat raised beyond the Po (Italiâ Transpadanâ) or in what is now called Venetian Lombardy. For he states such wheat (and, as I should infer from his phrase, at a maximum) to weigh, per modius, 25 money pounds, equal to 300 ounces: now 16 pounds of 18 ounces would produce 288 ounces; and, if we suppose his statement to have been a maximum, and place the average at (say) 24 pounds, we would have exactly the 288 ounces for the modius.

I should not have been so diffuse upon this point,

had it not been for the sake of illustrating how many technicalities and modes of account in commerce, arbitrary as they may at first sight appear, have grown out of the old distinction of wine and wheat weights, combined with the varying weight of wheat in the different countries where such modes of account originated. For instance, in the old Roman times, the long hundred-weight was of 125 pounds—almost exactly in proportion to the nett hundred, as the specific gravity of wine is to that of wheat; and, taking the first commercial pound of 16 ounces as the unit of nett weight, in the proportion of the Italian pound just mentioned of 20 ounces. An old English long hundred-weight was of 108 lb. for wax, sugar, and some other commodities: but it is stated at the same time that the said pound was of 25 shillings, while the pound for money and medicine was of 20 shillings. The ratio of these pounds is as 12 ounces to 15 ounces, or very nearly as the weights, in Gascony, of wheat and wine; but the nett medicine hundred and the gross sugar hundred are in the proportion of 12 ounces to 16 ounces, and indicate therefore the introduction of the Roman avoirdupois pound. Finally, our present long hundred and long ton are in the ratio of 18 ounces to 16 ounces, or that of the weight of Lombardy wheat to the ordinary commercial pound.

Some of the English writers on Weights and Money suppose the origin of these long hundreds to

have been in what may be termed the *customs-pound;* by which $12\frac{1}{2}$ or even 20 per cent. was allowed to the merchants for wear and loss: and which allowance, within those limits, might vary according to the more or less perishable nature of the commodity and the wants of the sovereign or government, taking the customs. They paid duties, for instance, on the pound of 18 or 20 ounces, but sold by the pound of 16 ounces. This may very well have been the historical fact; but what I may term the geometrical fact, viz: the principle of calculating the proportionate allowance and the value in ounces of the respective pounds, seems to me to repose very plainly upon the grounds I have indicated.

To return from this discussion. The third way of construing the Silian law, is to suppose that, between the two measures of capacity, the framers of it intended a proportionate equality in *weight and measure combined.* And this seems to me the best founded. I do not deny that dissimilar practices, proceeding upon both of the other interpretations, and leading to the introduction of the various pounds which have been mentioned, may not have grown up even within two centuries from the enactment: but they originated in a misapprehension of the meaning of the law, just as we shall see presently from a similar misapprehension of a written law, accruing in a shorter time, arose the confusion which destroyed the old Saxon proportionate uniformity of standards.

This Silian rescript was no doubt the less lucid, because it aimed at being but the exposition of existing usages, which tradition had made familiar and which habit had sealed and would, it was expected, render permanent: but still its very phraseology leads to this last interpretation. The sentence in which the liquid and dry sextaries are mentioned in connection, is the only one where the words "equal with" are employed. Now equality is not identity. And if the statute had meant the two measures to be identical either in volume or in weight, it would have said that the liquid sextary should be the dry one, or vice versâ; just as it says that the quadrantal of wine shall *be* eighty pounds, not shall *be equal with* eighty pounds, and again that the congius shall be (not equal with, but) six sextaries.

This rule of interpretation corresponds with the genius of the languages, equally of the translation and of the original; and it is confirmed by considerations which belong exclusively to the syntax of the latter, and from which we are warranted, I think, in supplying the words for expressing the essential idea, to wit: that when a sextarius of wine was balanced with a sextarius of wheat, the arm of the balance should be *level*, which last word is the literal meaning of the Latin *æquus*. And this is what is meant in saying, that there should be a proportionate equality in weight and measure.

Now a sextarius of wine weighed, as has been

already said, 20 ounces, allowance being made for the weight of the vessel; and a sextarius of wheat (struck) to weigh as much, and with the same tare, would have to be between one-third and one-fourth more capacious. But as wheat is not estimated in such small measures, it was not necessary in the law to refer to them any more than to indicate the principle of adjustment. It therefore ascended to a larger unit, substituting pounds for ounces in the computation; and, deriving that from an even multiple of the congius, fixed its ultimate value by *weight*. Thus, two liquid congii with wine would weigh 20 mint pounds, and with wheat, 16 of the same pounds; this last number was taken up as the nominal unitary weight of the modius; and in order to retain for it the real weight of the congius also from which it had been derived, there was applied to it the metrical weight, or libra—computed to contain as many ounces (sixteen,) as had been found of wheat in the liquid sextarius. The ascent, therefore, was made from the sextarius,—the transition from the congius; and the different pound-weight, which had thus become authenticated, was properly called the *metrical* pound, because it contained just the number of ounces that had been met with in the first step of the process. The Greeks, from whose language the phrase was originally borrowed, used it more appropriately in another connection. With them, it was a *measure* of a pound, not a *weight;*

just as our apothecaries now have their fluid-ounce, which is in a literal sense a metrical ounce.

Had the contrivers of this system, neglecting the symmetry between the result with ounces and that with pounds, sought to establish an identity of proportion between the pounds themselves, the libra would of course have contained a smaller number of ounces, viz: fifteen; for the 20 mint pounds of wine contained 240 ounces, and 16 market pounds of wheat, at 15 ounces the pound, would contain 240 ounces too: but both the variation in absolute weight was abundantly justified in experiments upon the different growths of wheat to be found in the Roman market, and also the commercial pound-weight, although it would have been a *proportionate*, would have ceased to be a *metrical* pound.

It was possibly an overlooking of this which induced the Roman settlers in Britain, or the Saxons afterwards when they brought in a new pound, actually to adopt this proportion for the ounces. And they would have been sustained in this misapprehension, had they resorted to experiment: for the wheat of Gaul, with which the agricultural depression consequent on a military occupation caused them to be principally supplied, weighed, according to Pliny, just 240 ounces (16 fifteen-ounce pounds,) the modius. This was the lightest wheat of which the Romans knew; and would shew a specific gravity little less than what is accepted at this day.

It is very possible, too, that the fact of the Silian law, as we have seen since with some other laws, hastened the very contingency against which it was intended to provide. Attempting to ascertain and to tie down ideas to words, it did but increase the doubts; and gave rise to innovation, while the aim was only revival. Such an innovation we must consider to have occurred in the assignment, but a few centuries after, of the number of sextaries, (to wit, sixteen) the aggregate of whose capacities went to make up the modius. This was an application of the principle, which the Romans accepted as we do, that other things being equal, the volumes are inversely as the weights; but it was a misapplication of the facts in the particular case. It followed the metrical proportion in terms, on the one hand; but on the other, it introduced a mode of determination for dry capacity-measures, which the law had not recognized and which the framers of the law could not have adopted, unless they had believed all wheat, of whatever growth, to be of the same specific weight. It recommended itself, however, to general application at first by its correspondence in terms, though not in fact, with the proportions it meant to indicate, and thus by its ease of remembrance; and it supported itself afterwards under question, by the result of experiments, within the variations that I have already mentioned.

I shall conclude this disquisition, which I hope will

not be found too long for the interest of the subject, by presenting in one view the relations of the Roman weights and measures, as far as they admit of tolerable ascertainment, with those that appear some time after the Norman conquest to have been of legal acceptation in England.

ENGLISH PROPORTION.			ROMAN PROPORTION.	
Foot;	1	:	0.9670	Pes; from the Cossutian monument.
Inch;	1	:	.	Uncia; in both systems the 1-12 of the foot.
Pace;	1	:	.	Passus; in both systems, equal to 5 feet.
Mile;	1	:	0.9157	Milliare.
Rood;	1	:	1.2365	Actus; in both, multiples of a furlong.
Pound (Tower);	1	:	0.9714	Pondo; Libra of 12 oz.
Ounce;	1	:	.	Uncia; in both, the 1-12 of the pound.
Pound (Com'cial);	1	:	1.0361	Mina; of 16 oz.
Gallon (Wine);	1	:	0.9042	Congius; in both the 1-8 of the cubic foot.
		:	0.9620	do. ; the so-called stand'd of Vespasian.
Gallon (Corn);	1	:	0.9684	Semi-modius.

This table is sufficient to shew at a glance,—what was affirmed a little while ago,—the influence which the Roman system had upon the composition, and the denominations even, of the weights and measures accepted more than a thousand years afterwards in England. That it shows the introduction and permanence of the Roman units too, I do not see any necessity for admitting; although such would be claimed by some writers who see in our present avoirdupois pound, for instance, but the restoration of the old Roman weight.

Such acceptation of Roman units, seems to me to receive little countenance in the history of the Saxons, both prior to and at the time of their settlements

in Britain. Descended from those terrible Scythians and their most illustrious tribe, the *Sacæ*,—who, as far back as the time of Herodotus, had crossed from Asia over the Dardanelles or the Bosphorus or both, and expelling the Cimmerian clans, had settled themselves in and around the Thracian Chersonese,—the "People of the Sword," (as their name implies) were, at the time of the Roman invasion of Britain, spread north and west, along the course of the Danube and the waters of the Elbe; and occupied under a general name, then recently introduced but equivalent in signification to the original one, a great part of that portion of Europe which we now call Germany. Finding again in a new Chersonese, and driving from it, their ancestral Cimbric foes, they learned on the shores of the North Sea the art of ships; and even without that famous periplus of the Frank colony of Probus, which served as a fresh stimulus to reap the harvest of the sea, four hundred years of successful piracy would have taught them all the approaches to Belgium, Gaul, and Britain.

About the close of this last period, the Roman Empire,—now weakened by excessive extension, maintaining a more doubtful seat because of its already double throne at Rome and at Constantinople, and threatened in both,—needed all the help that it had formerly spared for its remoter dependencies. Britain, depeopled even by the legionaries it had supplied, was abandoned by Honorius and the Ro-

mans at last and forever; and the Islanders exchanged the comparative security of a colonial existence for a precarious and troubled independence. Split up, perhaps at once, certainly before long, into many local governments, subject to the forays of the Gaelic and Celtic tribes who had evaded the Roman yoke and whom the unsentinelled wall of Severus now kept off no more, and menaced from time to time by these very Saxon sea-robbers, the head men of Britain proper, with plausible policy, employed one of these enemies against the other. How this employment was negotiated,—whether Hengist and Horsa were regularly invited over, or cognizant of the state of affairs preconcerted themselves to come, or accidentally at hand were availed of by the ambition or timidity of Gwrtheyrn (the poetic Vortigern)—is for our view of no account: the first Saxons came with the prospect before them of a permanent settlement, the additions to their number were frequent, regular and large, and it is probable therefore that along with their language and habits, their maces and swords, they brought their weights and measures.

This point, however, is neither worthy of being treated here with much diffuseness nor susceptible of any definite conclusion. Within the eight centuries that elapse, from the period I have just mentioned, to the time when we meet with a systematic establishment of this matter, the dissevered principalities,—usually included under the generic appellation

of *Saxon*, though not strictly so,—were disturbed by Danish invasions and settlements; and all were ultimately absorbed under a Norman conqueror and his companions. The estimation of the influence proper to be ascribed to each of these events and its consequences in the modification of Weights and Measures, demands a scope far more extended than the compass of this Report.

It is true, the constitutions of the Conqueror expressly declare that no alteration shall be made, in this respect, from the establishment of his predecessors. But that establishment is hardly to be spoken of in the singular number, since his very laws also shew a want of uniformity between the West Saxon and Mercian computations; and we know besides that it was himself who abetted in England the then habitual continental computation of shillings and pence, assigning for both relative values quite different from what had been recognized under any of the Saxon customs. It is proper to add, however, that this innovation extended no farther than to the coins; and that the weights and other measures, for all that appears, remained or at least were intended to remain, regulated by the Saxon standards.

To confine myself, therefore, within a due brevity, I shall treat these standards and their methods of combination under the general aspect of English weights and measures; without distinguishing otherwise than incidentally between what were actually of

Saxon, Danish, or Norman origin and habit: and as this relieves from the diffuseness belonging to any chronological order of exposition, I shall condense every thing that is to be said down to the present time under classes of Measures, similar to those which have been made in the former part of this Report.

1°. *Measures of Length.*

The name of the unit in this measure—the *yard*—which has subsisted to this day, forbids the supposition of a Roman origin. It means the *girth;* it was, most likely, the average circumference of the unclad chest of the stalwart Saxon race. In taking such a derivation, they were altogether peculiar: the rest of the continent of Europe measured lineally by the *foot;* the older Asiatic unit was similarly a linear measure, the *cubit.* Both of these last standards were in harmony with the pursuits of the people who employed them; the one with the pastoral repose of the East, the other with the agricultural activity and peaceful thrift of the West. But the warlike Scythians may be supposed to have adopted one, more connected with the violent muscular exertion for which they had daily call; they may have perpetuated it, in the length of their characteristic swords. It is difficult otherwise to reconcile the name with the thing; although the subdivisions of it, or its computed value, no doubt were early reconciled

with the habitual measures of the nations whose territories they occupied. But this early reconcilement must have been made with the *Greek* foot, if we trust any thing upon the agreement of measures—not the Roman, from which the Saxon foot systematically varied. It was, however, from the fractional computation of this last, as was given just now in the comparative table, by twelfth parts or *unciæ*, that the English denomination and proportion of the *inch* was borrowed. We are warranted, then, in concluding that the Saxon yard, when it was generally accepted in Britain, coincided with 3 Greek feet; and it was divided after the Roman account which had been used in the Island for half a thousand years, into 36 inches as at this day.

Such a conclusion may be still admitted, even if we attach credit to the tradition that places the determination of this standard in the time of Henry I; that a prince so provident should have revised the measures of his kingdom is quite probable; that one, whose proficiency in knowledge more than common won for him the name of *Beau-clerc*, should have employed proper means and principles, is still more so. There is no physiological impossibility in the coincidence between the old Saxon yard and the length of the monarch's arm, especially if in such arm's length is included, as it was elsewhere, half the diameter of the body: but, historically, the fact altogether is more than doubtful.

More than a century later, a coincidence of another kind but in the same way, was noticed; and has come down to us in an existing law. The precise epoch of that law is uncertain; in some old editions of the Statutes it is referred to 33 Edward I, A. D. 1305; probably it expressed a much earlier tradition. It says "that 3 barley corns, dry and round, make the inch

12 inches	the foot
3 feet	the yard
5½ yards	the perch

and 40 perches in length and 4 in width the acre."

It goes on to exhibit a table for Land-measure; and then, returning to linear measure, winds up by saying, "that the iron yard (ulna ferrea) of our lord the King contains 3 feet and no more; and the foot should contain 12 inches: that is, the inch be the 36th of the yard—and 5½ yards ought to make the perch, that is 16½ feet, measured by the aforesaid iron yard of our lord the King." It is hence plain that the barley-corns, as the inches, were merely indications not constituents of the standard; which is expressly the "iron yard aforesaid," very likely dating up to the time of Henry Beauclerc.

Precisely the same indication had been made long before in Wales. In the Venedotian Code (as it is called in the Ancient Institutions of Wales, one of the recent fruits of the Record-commission of Great Britain,) presumed to contain the laws of Howel Dda, the Welch Alfred, and to have been composed

about A. D. 1080,—the measures for the mile are given, as follows:

3 barley corns	in 1	inch
3 inches	in 1	palm-breadth
3 palm-breadths	in 1	foot
3 feet	in 1	pace
3 paces	in 1	leap
3 leaps	in 1	land
1000 lands	in 1	mile."

The uniform triplicity in this system, up to the land, reminds the student in the Cymraeg archæology of the triads; by which the Welch bards associated in their songs, ideas having or supposed to have (for the connection is often highly fanciful,) some resemblance or affinity. One of the Codes, even, in the work I have mentioned, is made up of such triad proverbs. No doubt its exemplification, wherever it occurs, had some common origin.

Thirty years before the date of the English statute just now given, the principality of South Britain had been annexed to the crown of England; and Edward of Caernarvon first wore the title of Prince of Wales. The law, therefore, applied in that district; where, either aboriginally or from Saxon proximity, there was an habitual measure used in fact as the unit of land-measure, which accorded with the English standard. This appears from another passage in the code of Howel the Good, relating to the *erw*, or acre. After carrying on the same multiples from the barley-corns to the foot, this passage recites, that

"4 feet are in 1 short yoke." Now 4 feet of 9 inches are 36 inches; just the length of the English yard. I shall not stop to shew how this short yoke may be averred to be in fact the unit of length; but recuring to what I first said, that the subdivisions of inches and barley-corns at least were but coincidences not constituents, I shall make but one more reference to these Welch laws in illustration. It is the part of the same Venedotian code, prescribing the capacity-measure in which a cow, affirmed by the buyer to have been imposed upon him as a milch-cow, is to be milked: after giving four dimensions of the vessel with great particularity in inches, it winds up by saying that "the inch is the breadth of the judge's thumb."

I have rendered the original word (*ulna*) in the so-called statute of Edward I, unhesitatingly by our word *yard:* because they were both composed of 36 inches. And I presume that the same thing is meant by the *due ulne infra listas* which, as defining the unitary breadth of all coloured cloths and russetts, occurs first in the Magna-charta of King John at Runnimede; and is regularly repeated, through the eight succeeding and still preserved Anglo-Norman Great-charters, down to the very period of which I am speaking. But this *ulna*—a yard—must not be confounded with another *ulna*—an ell—as is sometimes done; nor the words, yard and ell, used as synonyms. The last, the ell, came in later; is sup-

ported by a lately existing standard of Queen Elizabeth's reign, as being a yard and a quarter, or 45 inches; and, in that proportionate length, may be presumed to have been borrowed from the Paris drapers' ell.

The very standard, referred to in this statute, is not now in existence; but there is good reason for presuming that its absolute dimension has been preserved. A succeeding statute (14° Edward III; A. D. 1340,) directed that the treasurer should have made "correct standards of brass for the bushel, the gallon and weights;" but nothing is said of a measure of length: nor is it until 1491 (7° Hen. VII) that there is any more mention of standards to be constructed. As there was (previous to 1834) in the Exchequer of Great Britain, a yard measure of brass (the metal spoken of in the act) with the stamp of this Prince; and as in the recall by him, five years afterwards, of erroneous standards of capacity, no reference is made to the length measure, we may conclude that the late yard was the very one made under this act; that it was a copy of the iron measure of his predecessor; and that, being taken as a full substitute, it led to the disregard and final loss of this last.

The yard of Henry VII appears to have kept its place as the standard, till in its turn it was replaced by a yard and matrix in the reign of Q. Elizabeth (30° Eliz. A. D. 1588). This last, though succeed-

ing sovereigns caused others to be constructed and left in various other depositories, was, for a long time after, the sole Exchequer standard of length.

It was not until 1743, that any thing like a critical examination and scientific determination of these various measures, was had. In June of that year, Mr. Graham made, at the instance of the Royal Society, with the assistance of several other members and with a suitable apparatus, the necessary investigation. He compared the two standards I have mentioned at the Exchequer, and an ell (of 45 inches) of Q. Elizabeth at the same place; a yard and ell matrices at Guildhall of Charles II and William and Mary; a yard of the Clockmakers' Company of Charles II, and a yard, belonging to the Ordnance and kept at the Tower, of George I. The mean of all these six yards and matrices (the ells being omitted) was . . 36.0058 inches.
the yard of Q. Elizabeth being taken as 36.0000
and the old yard of Henry VII, found to be 35.9929
He made also a copy of the Q. Elizabeth standard for the use of the Society; destined to perform, some time later, a more important function.

In 1758, the House of Commons raised a committee, "to inquire into the original standards of weight and measure in this kingdom, and to consider the laws relative thereto." This committee made a first report in the same year, touching the standards; and a second in 1759, touching the sta-

tutes: to both of which I shall have occasion to refer again. As far as the measure of length is concerned, the committee found the exchequer standards in what they considered an unsatisfactory condition; and they preferred to derive the unit they wished to present to Parliament from Graham's copy for the Royal Society, which was regarded as having been better preserved. Accordingly they engaged Mr. Bird, the most eminent mathematical artist of his time, to make two standard yards from this copy; and they reported one of them with which they were best satisfied, marked with the date 1758, to be accepted as the unit of length. The other, of which they make no particular mention, I consider as being the one subsequently found by Sir George Shuckburgh to be dated 1760. This was attributed by him to another committee raised, as he supposed, in that year: but I have met with no other evidence of such a proceeding, and I take the date to have been affixed upon some later examination by the same committee. This is however of very little importance. Both of them, whenever made, were undoubtedly executed by Bird; upon whose skill the committee appear to have unhesitatingly relied. In this particular case, there was indeed the more reason; a trusted workman in the shop of Sisson, where the Royal Society yard was got up for Graham, he had most likely done the mechanical part of that and so came to be familiar with all the standards. When

he attained afterwards a reputation on his own account, he made divers scales of yards and multiples of yards; which were deservedly in high respect and tended ultimately to modify the standards.

In 1760, bills in conformity with the recommendations of the committee were brought in by the chairman, read twice, amended, and in preparation for being passed by the House; by which among other things, one of these copies by Bird would have been accepted as the standard yard: but a prorogation occurred before the bills were entirely ready, and so the matter was lost for that time. As I have always found this occurrence placed in the formal histories of the period under the date I have given, I presume that the one of 1765, attributed to it by a parliamentary report of a Weight and Measure committee in 1816, is either a misprint or an accidental error. At either period, however, there were subjects, if not more important at least more exciting, to occupy the legislature; just as there were again in 1790, when a fresh committee was appointed to consider the standards, whose investigation (if they made any) left no remaining trace.

About the year 1774, the idea of an invariable and universal unit of linear measure began to develope itself in England, as it did in fact elsewhere; the pages of the scientific journals of that period, as well as of more elaborate authorship, abound with inquiries into the origin and proportions of Weights

and Measures, and with suggestions as to a uniformity which the growth of physical science was every day rendering of more interest. In England especially, the early ideas of Wren and Huygens, in regard to the employment of the pendulum as the measure of length, were being revived; and in the year I have mentioned and for several following years, the Society for encouragement of Arts, etc. offered a prize to the successful investigator of this or any other method. But the time was not yet ripe for the developement; and the call of the Society was only a demonstration of failure. Some time later in France, indeed, when the phenomena of the pendulum were taken up as collaterals to the metrical system there, Borda shewed how, through a complicated analysis, the mechanical difficulties could be obviated: but the Saxon intellect, essentially synthetic, waited for a mechanical revelation or, in our phrase, a practical way. This—the convertibility of the centres of suspension and oscillation—was first suggested by Bohnenberger, more than thirty years, and was independently exemplified by Kater, more than forty years, after the time of which I speak.

The prize-call of the Society, although abortive in its special aim, was however fruitful, indirectly, of momentous consequences to English weights and measures. Not to mention the ingenious experiments of Whitehurst, it stimulated Sir Geo. Shuckburgh Evelyn to a revision of the comparisons of

Graham and Bird. In 1798, this savant published his results. For making the comparisons, he had procured from Mr. Troughton—an artist, who in all respects filled the place of Bird, and more—a scale of inches, each the thirty-sixth part of the standard yard. Whence Troughton derived his values, is not positively known: most probably, by the coincidence and Troughton's avowed high opinion of Bird's accuracy, from some scale of Bird's make. The mean result of seven measures in the Exchequer, in the Commons' archives, in those of the Royal Society, and in the Tower, gave a value for the yard, within $\frac{1}{1000}$ of an inch of what had been assigned by Troughton's scale; and the greatest difference among these and six others, most respectable copies, occurred between the old standard of Henry VII, (which, after all its long use, was only $\frac{7}{1000}$ of an inch too short,) and the matrix of Guildhall (that use would tend to lengthen, and which was $\frac{3}{1000}$ of an inch too long,) to the amount of one-tenth of an inch.

	inches.
Taking a mean on Troughton's scale, of	36.000
the yard of Henry VII was . . .	35.924
and that of Q. Elizabeth	36.015

If, then, we take the yard of Henry VII as the equivalent of the iron yard of Edward I, we are warranted in saying that, for all practical purposes, the scale of Troughton and that old standard are identical.

I have insisted the more upon this Troughton

scale of Shuckburgh, because it has come subsequently to be the real standard measure of length in the United Kingdom. In 1818, a Royal commission was appointed, according to a resolve of Parliament four years before, "for considering how far it might be practicable and advisable to establish a more uniform system of Weights and Measures;" and one of its necessary functions was, of course, a revisal and comparison anew of the old standards. And such comparison was the more necessary, in order to see how far the adoption of certain ideas which the Commission favored in respect to the basis of the new system, would deviate from what had been recognized in the old. One of these ideas, for instance, was that the standard yard should be derived from the measurement for the Hounslow Heath base-line of the trigonometrical survey, that had been executed, some thirty-five years before, by Gen. Roy. The length of this base-line rested upon that of an iron bar of 20 feet (*à traits*) made by a very excellent artist, Ramsden, for the purpose, and ultimately upon a brass scale, the property of the same artist; and both were averred to agree precisely with the Graham Exchequer standard of the Royal Society. The same agreement was averred also for a Bird scale, the property of Roy. The Ramsden brass scale could not be found; but the other three were accessible. These were all compared in 1820, by the late Capt. Kater, one of the Commission, an

accurate and skilful observer; and along with them,—Bird's parliamentary yard of 1760, which has been before mentioned,—another yard scale, *à traits*, of the same artist, constructed for the use of the Anglo-Indian survey under Col. Lambton,—and the Troughton scale of Shuckburgh. Shuckburgh had already said that the 1760 Bird yard differed from his scale within $\frac{2}{10000}$ of an inch: the result of Kater's comparisons was, (taking the Lambton Bird scale, which was the shortest of all, as the zero) as follows:

	inches.
Lambton's Bird yard, . . .	36.000000
Sir Geo. Shuckburgh's standard, .	36.000642
Bird's Parliamentary yard of 1760,	36.000659
Roy's Bird scale, ...	36.001537
Royal Society's standard, . .	36.002007
Trigon. survey's Ramsden iron bar,	36.003147

This result, of course, placed the standard of the trigonometrical survey out of the question; and the commissioners recommended, in a second report of 1820, the adoption of Bird's Parliamentary yard of 1760 as the foundation of all legal Weights and Measures. Parliament, four years afterwards, accepted the recommendation and declared the said yard, under the denomination of the Imperial Standard Yard, to be the "unit or only standard measure of extension" of the United Kingdom; as it remains to this day. But as the difference, shewn in the above table, between this new Imperial standard and

the Shuckburgh scale is so slight (only seventeen millionths of an inch,) and as, indeed, six of the twelve comparisons made by Kater between them, and two other comparisons made by Wollaston, the most reliable observer of his day, had resulted in absolutely no difference at all,—the two scales were justly taken at the time to be perfectly identical. In this view, fac-similes of the Shuckburgh scale, executed by the same artist at private instance,—have been extended to the continent of Europe and serve for the conversion of measures there into those of English estimation, and reciprocally; copies of the English yard and inches, compared by the same observer Kater, have been made by its means for communication to several of the European governments; and finally, it is from a Troughton fac-simile (except as regards the number of inches) of the same scale and apparatus that flow all the comparisons for and ultimate determinations of our present Standard Yard of the United States.

I am, therefore, justified by all these momentous consequences, in ascribing to this scale of Shuckburgh the importance that I gave it just now in calling it the *real* standard of Great Britain and, I might add, of the Anglo-Saxon family. The Commission, indeed, (or rather the working member of it, the late Captain Kater,) convey by the language of the scientific account of the new Standards of Great Britain and Ireland, committed to the pages of

the Transactions of the Royal Society, the idea that their weights and measures "are founded upon a standard, the length of which is determined by the proportion it bears to that of the pendulum vibrating seconds of mean time in London." But such an idea must be only accepted in a peculiar and restricted sense. If by some all-whelming catastrophe, the now existing standards of the English yard and inches should be swept away, it is true that their value (excepting errors of observation) could be recovered from the measure of a pendulum beating seconds in London, or elsewhere, by an appropriate correction: but until then, the value of the yard will always be derived, by a much more patent and unexceptionable experiment, from the Shuckburgh scale or some sufficiently respectable copy of it. After a catastrophe, similar in kind but much less in degree than such a one as I have premised—I mean the conflagration of the Houses of Parliament in 1834 and the destruction there of the Imperial standards—I have not heard of any resort to the pendulum to effect the restoration of the latter.

If the phrase of the account of Capt. Kater had been, *may be determined*, instead of *is determined*, it would have been literally accurate; but as the case actually stood until 1834, the standard was *not* determined by any reference to the pendulum: the length of the pendulum was determined by reference to the standard. In fact, speaking historically, the pendu-

lum has nothing to do with the standard farther than a coincidence; and speaking popularly, no more than the barley-corns of Edward I, had to do with his iron yard. Speaking scientifically, these averments would of course have to be qualified: but even in this last aspect, the pendulum is no more an element of the English metrology than it is of the French, where indeed to its interposition is assigned the proper rank. The conduct in the latest establishment of each of these systems, serves to exemplify—I will not say the fallacy or the inutility, but—the inconsistency of those aspirations after an absolute and invariable standard, which animated the pursuit in both. The one, claiming to be determined by a phenomenon of Nature's most universal law—gravitation—yet reposes, actually and in terms, upon the space between lines traced on a brass bar for Sir George Shuckburgh; which space was obtained by a series of (so to speak) material traditions from and compromises among ancient standards, of origin if not accidental at least not refined: The other, more ambitious still and aiming to girdle the globe both morally and physically, in practice had to measure each successive step of its profound and wide-reaching investigations, by the space included between certain lines on the so-called toise of Peru; which, on its side, grew out of successive traditions from the ancient measures of the kingdom. All this serves farther to shew the interest attaching to every

undertaking, like the present, to guard and perpetuate such traditions; and even if one should not be satisfied that standards so handed down, bear a sanction of the highest order (in being symbols of intellectual and moral, instead of merely physical, manifestation,) at least it is not to be doubted that the operations in fixing them are precisely the same, and therefore just as important, as those upon which an Establishment for the Universe, were such a thing possible, in its earliest stage must rest.

2°. *Measures of Weight.*

As in the Measure we have just now been considering, the distinctive appellation given to the unit indicates a Saxon origin, so also does it in this case. The English pound and penny bore, in ages far remote from ours, the denomination of *Sterling* or *Esterlin* as they do now. That this indicates no *Roman* identity, at least, the writers on the subject are nearly unanimous; but the tracings of its etymology, prior to 1745, have been as various almost and as numerous as the writers themselves. In that year Martin Folkes, then President of the Royal Society, an accomplished numismatologist, first announced in his Table of English Silver Coins (already referred to,) and upon the authority of a verdict relating to the coinage preserved in the Exchequer from the time of Henry VIII, the value of the Saxon pound in terms of Troy weight. The proportion between

them, as 15 to 16 or as 5400 grains to 5760 grains, excluded all reference to origin from the Romans, and shewed that, after their occupation ceased, a new unit must have been substituted. But this announcement did not settle the derivation either of the name or of the thing; and authors have been as discrepant since as before. Among derivations so omnigenous as *Estâr*, the Saracenic word for the Greek coin, the Stater—*Star*, the Hebrew word for an indenture or written obligation—*Steore*, the Saxon word meaning a standard—*Stirling* Castle in Scotland—the speaking bird, the *starling*—who shall judge? The epithet *Easterling*, which to a weight coming from Heligoland, nearly due East from Britain, would be quite appropriate, Bp. Hooper denies to it from that quarter, to place it more probably among the rich merchants on the South-east or Mediterranean Sea: though he rejects both, and prefers to find it among the Saracens. Others have discovered, as they suppose, that the mint-workmen came from Germany; and have even fixed the epoch of their advent in the reign of Richard Cœur de Lion. Only one writer, Clarke, has seized the obvious physical and historical analogies; and has presumed it to be the old pound of the Asiatic continent, whence the Saxons came. It was thus, from the moment they planted themselves on the European shore, an Easterling pound; and each successive step in their subsequent western migration only gave fresh reason for the name.

It is impossible now to ascertain positively what the divisions of this pound were, for many centuries after its European use: but the subdivisions of it in account, no doubt very soon accorded with those habitual in the provinces under Roman domination. In the earlier times of Weights and Coins, the mint pound and the pound of account were identical; the silver coin was a corresponding nummulary weight; and the denarii, for instance, (the Roman mint units after the introduction of silver,) were reckoned at 84 to the pound, because each such piece was, as near as the then imperfect art of coining could make it, $\frac{1}{84}$ of the pound weight of silver. But as the circulation of this money was extended, as experience detected and use magnified the deviations (which would be always on the side of light weight) in the mint, an allowance was made on money paid *in tale* to cover the defect in absolute weight. The kind of this allowance was the same with,—the degree of it not materially different from what had been before admitted in the exchange between articles sold by measure and those sold by weight; and the coinage itself was after a while regulated accordingly. Thus, to keep to the instance just mentioned, the pound of silver was intended to be cut up into 84 pieces or denarii; it rarely produced that number exactly, first because it required a certain perfection in the workmanship, and secondly, because the State or the sovereign gained every additional piece that

could be coined over that number. But such a discount could not be made, systematically or for a long time, without detection; a corresponding premium was demanded by those who received money; and the denarii appear to have been rated at 100 to the pound, before the Imperial necessities had actually changed the coinage from 84 to 96 pieces out of the pound weight, that is, from 7 to 8 in the ounce. This computation was perhaps supported too by the Greek commerce; the Roman denarius and the later Greek drachm hardly differed in weight; and these last had always been by the centesimal count.

At all events, in the earliest times of the Byzantine Empire the *centenionales nummi*, the silver cents, replaced the old denarii; the poverty, that like an armed man followed with irresistible tread the luxury of the successors of Constantine, rendered expedient an actual decrease in the size (keeping, however, the old denomination) of the coin with which the military establishment of the throne was supported; and hence we may trace the use, among the Franks and other nations in Germany, of the ceratium or quinarius of 200 to the pound, as their unitary silver coin under the name of denarius. It was, in weight, the half-denarius.

Now, if the minting was accurate and 200 denarii (so called) were really struck out of the pound of silver, the same proportionate allowance as before,

between weight and tale, would make them pass when counted at 238.5, or, in round numbers, at 240 to the pound. This number of denarii or pence to the pound, was certainly admitted all over Europe not very long after the Saxon occupation of Britain: that it arose from a degradation in the mintage of one-fifth, seems to me deficient in historical proof; at least those, who advance such an opinion, have omitted to indicate the precise epoch at which the degradation averred took place.

Whether the Anglo-Saxon count, of 240 pence in the pound, was borrowed from this Frankish count: or whether it originated long before in the proportions of the older Greek pound—from which, for instance, we have derived the weight of the *journey*, (as it is called,) of silver to be minted, viz: 60 lb. or the *Talent*,—I shall not enquire. Both, probably, contributed to the result.

With 240 pence to the pound, the universal subdivision of the pound into 12 ounces, makes 20 pence to the ounce; a proportion, affirmed in the first precise English statute remaining on the subject. It is the same proportion that we have to this day. The division of these pennyweights into 24 grains was the old way of the Romans; who counted 24 lentes to a scriptulum or scruple, the smallest of their marked weights. There is no direct evidence of such a subdivision in the Saxon pound.

It was in accordance with these proportions, that

the money-weight was regulated, though under different denominations. The pound of silver was reckoned by coins, in shillings and pence; the same appellations used in England now, but conveying neither the same absolute nor relative values as then. The Saxon shilling or *scyllinga* was the Roman *sicilicus;* which, as a weight, was $\frac{1}{48}$ of the pound and, as a coin, corresponded to the value of the old double-denarius or didrachm. Whether the Saxons corrupted this name in Roman commerce either in Germany or Britain, or had it before from an Eastern source, I shall not stop to discuss; the vanity of the Latin authors would have one believe that it was indigenous to their tongue. But the very etymology they give, strains and weakens the claim; it is hard to make the sound of *sicilicus* out of *semiunciam secans;* and a more particular investigation than can be afforded here, would perhaps determine our finding the analogue of the term, as we do of the thing, in the Greek *siclus* and Jewish *shekel.* It has, however, hitherto hardly less exercised the ingenuity of philologists than the epithet *sterling*.

Be this as it may, there is evidence as far back as the Dano-Saxon laws of Edward and Guthrum, about A. D. 920, that the shilling was worth 5 pence; and therefore, with 240 pence to the pound, it was just $\frac{1}{48}$ of the latter. In *tale*, they might have been reckoned at 50 to the pound, just as we know was the case of the Greek drachm and Italian denarius;

which serves to reconcile the arithmetic of some of these laws with the rest. That the shillings fell to 60 in the pound afterwards, would appear from the laws of Athelstan, the successor of Edward the Elder, (about A. D. 924,) in one of which the levy of 4 pence is called the King's shilling; and again, from a law of the Conqueror, which says that the English *solt* is 4 deniers. The number of deniers, or pence, in the pound having remained constant, there must have been in it, also, sixty pieces of 4 deniers each.

Such is the conclusion of some of the English writers: which is of no great concern here either to admit or disprove. I will only remark in regard to the law of Athelstan, whose necessities have been taken as a plausible reason for his lowering the value of the coin, that it is quite likely he should have done, as Governments laying a tax not unfrequently do still, viz: allow a premium for early payment. The law itself required from every one whose income was 30 pence, a shilling to be paid within twelve months; now, in estimating a proportionate tax, a shilling of 5 pence is an aliquot part of 30,—it is the sixth part, which was besides exactly the multiple employed in a good many other taxing and penal laws of the period. An income of 60 pence would yield two shillings, and so on. Farther, this proportion of 48 to 60, or of 4 to 5, is exactly the ratio of the mint-pound of 12 ounces and the Saxon com-

mercial pound of 15 ounces; and Athelstan might be very well content, if he got his 4 pence, to let it be called a *shilling* (as it really was of the market pound,) and thus allow his subjects the consolation of thinking that the rate had been fixed upon the computation most advantageous to themselves. Finally, the sway of Athelstan was over the whole of that Octarchy whose dissevered state had been favorable to a want of uniformity in weights and measures. Some of his subjects had been habituated to the computation by the money-pound, while others seem to have used only the proportions of the commercial weight; and between the West-Saxon reckoning and that of Mercia the central and largest portion of his domain, there was centuries after precisely the ratio of 25 to 20 in the fines for identical offences. He, therefore, whose prescription that "there be one money over all the King's dominions" is the first of the kind we meet with in Saxon history, may have evidenced his attempt to reconcile these different computations in the very law that rates the old five-penny shilling at four.

To return from this, the pennies themselves appear to have remained for a long time constant. The Saxons called them *pœninga*, or, as in some remaining records, *pending;* in this, certainly borrowing from the Latin *pendo*, inasmuch as this piece was the unit of their coins and accounts. It was the key of the whole English system of weights and capacity-measures, long after the Norman times.

But these Norman times brought in with them, as I observed a little while ago, a great change in the relations which the shilling had to the penny; and the former, which fluctuated, as we have seen, according to locality and age, between five and four pennies, became under William the Conqueror and more uniformly and clearly still under Henry I, the solidus of twelve pence. This word, *solidus*, was introduced in the later times of the Roman Empire, to distinguish between the two sorts of *aurei* or gold pieces, which were then current; one of which was just half of the other in weight. The whole one was termed the *aureus solidus* or, simply, the *solidus*.

I may remark in passing, that it was from this solid *aureus*, that the Danes and Saxons corrupted their word *ora*; which, I have already said, meant in their laws the *ounce*. And this assisted in establishing the computation of 20 penny-weights to the ounce; for the weight of the *aureus* corresponding to that of two denarii and the then value of gold to silver being as ten to one, such an aureus was exchanged against 20 denarii or pence. The half aureus, or gold penny, then exchanged for 10 pence, as we know it did in the time of Pliny the Elder. But afterwards under the Byzantine Empire, when a substitute for these two aurei was supplied by one, that bore likewise the name of *solidus* for its sanction, and was to the former half aureus inversely as 72 to 84, either a calculation by a strict proportion of weights or a change

in the relative values of gold and silver within what we are assured did occur, or both, made this new aureus solidus worth 12 silver pennies of 240 to the pound. The Franks, who used it as a coin, called it a *solidus;* the Danes, who used it so too, called it an *ora:* and both rated it as $\frac{1}{20}$ of their silver pound. The Saxons, who employed it chiefly as a weight, reckoned it as 20 pennies and therefore equivalent to a mint ounce.

Later, during parts of the twelfth and thirteenth centuries, this appellation was given in England to a coin of the value of 16 pennies. But this was not the Danish *ora.* It was the Saxon half-mancus; which, being an *aureus* or gold piece, underwent the same corruption as its predecessor—a corruption which is perpetuated, as in the Portuguese *moidore* (moneta de auro,) in several parts of Continental Europe to this day. That this computation of 16 pence to the ora, was not formerly applied to other than coin-weights, is plain from a law of Ethelred, the predecessor of Canute, which directs: ut omne pondus sit marcatum ad pondus quo pecunia mea recipitur; et eorum singulum signetur, ita quod 15 ore libram faciunt. By misapprehending the scope of this, however, some writers have taken the libra here to be the money-pound of 240 pence: and thence deduced an ora of 16 pence itself. But it is manifest that the pound in question is the commercial pound, that was to be marked by the money-

pound, with which it is placed in direct contrast: and it is to be so deduced as that it shall consist of 15 oræ, instead of 12, as were contained in said money-pound. I may remark here, that this reckoning of 16 pence per ora, or ounce, has survived both of the money and commercial pounds from which it originated, and has been transferred to our avoirdupois count. It is hence that in this count we allow 16 drachms to the ounce.

We see, therefore, that the Continental solidus was not entirely new in England at the period of the Conquest. I have met with the term (for its first occurrence, I believe) in the Forest-canons of Cnut (or Canute) the Dane: but it seems to have been legalized as a method of reckoning, only after the Normans came. Whether it was actually coined of silver or not, which antiquaries have disputed, is here indifferent; in either case it was sufficiently distinguished from the old Saxon scilling, whose name it bore softened into *shilling*, by the latter's being very early termed a *gross*, or *groat*, and kept to its value of four pence. The conjecture is at least plausible, that this last appellation was bestowed upon the Saxon shilling, because it was (*die grosste*) the *largest* actual silver coin of the time.

As a nominal unit in accounts, it is certain that the Anglo-Norman shilling continued for some centuries, not only for money but for weight. An old law, of uncertain date but ascribed by some to 51 Henry III,

A. D. 1266, and headed an *Assise of Bread and Ale*, gives both the prices and the weights for bread, in shillings and pence of the same system. This document has been much criticised, as shewing a carelessness in the arithmetic of our English ancestors; but if any one will take the trouble, as I have done, to go over the thirty-nine articles of calculation in it, he will find that of the six errors which occur on the face of the statute, all but two are attributable to errors of the transcriber, which the insertion of a point in one case, and transposition and addition of one letter in the others, will correct. And of these two, the origin and mode of occurrence is so easy to be seen, that this law will bear a favorable comparison with those that I have detailed in the former part of this Report.

This correspondence of coin and weight continued until 1301; when Edward I struck out of the pound of silver 243 pennies, instead of 240 as before. From that time, the shillings and pence as parts of the pound, have been only monetary and nominal.

With the other Dano-Saxon coins, the *mancus*, (manu-incusa,) the *mark* (or *standard*) the *thrimsa* (tremissis) etc. the aim of the present Report has nothing to do. Those that have been discussed were only taken up because they explained or illustrated the English system of weights; and I shall terminate all that is to be said in regard to coins with a single remark, that a good deal of confusion might

have been spared, in discriminating the currency of the same coins in different countries, had due attention been paid to the relative values of the units of weight in those different countries.

Although Ducange had shewn (unexceptionably as we see now) the value of the Sterling or Esterlin pound as compared with the pounds of Troyes and other places, about the beginning of the fourteenth century, we yet find learned writers after him and even using his document, speculating upon the troy pound, which had become domesticated in the Engish mint, as if it came from Tours or, higher still, from Troy. This last fancy is of a piece with a yet existing early Anglo-Norman charter, that declares the City of London to have been founded and built up after the model of the Homeric Troy; or with the still earlier tradition that would make one of the children of Æneas, wandering either from necessity or choice over Europe, at length settle himself in Britain.

That the troy pound was not the pound of Tours, is plain from the following table; in which I have reduced Ducange's statement which he took from a Register in the Chamber of Accounts at Paris, and that of Folkes from the mint in London, to pennies sterling. I have added also a similar reduction of the Roman pound; which I have rated according to the estimation of Arbuthnot,—not that I think it correct, but because it is current. I have also made

a column, shewing the respective values of the mint-pounds, and another, shewing the corresponding market-pounds,—both expressed in troy grains. It will be seen that the Tours pound and the Roman pound are nearly identical.

	Sterling dwt. Ducange.	Folkes.	Troy grains in Mint-pound.	in Market-pound.
English pound,	240.	240.	5400.	6750.
Limoges do.	236.25	.	5315.6	.
Tours do.	232.50	.	5231.25	.
Troyes do.	255.	256.	5760.	7200. in 15 oz lb. 7680. in 16 oz lb.
Roman do.	232.23	233.14	5245.71	6994.3

It is from the inflections and permutations (so to speak) of these various pounds, but principally of the two last, that the present English standards have resulted. That inflections of this sort should occur is very natural and consistent; from the time of Athelstan, England began to take the rank in Continental Europe which she has since carried to such a height; and across the narrow strait dividing the two, the pulses of trade were communicated and typified in the weights and measures of the traders.

It is, besides, as impossible as it is useless to expect, in a matter of this kind, a precise historical epoch marking when this or that custom or reckoning was introduced. As in the physical so in the political world, the origin of what comes to be a mighty developement, is often so hidden as to be attributed to chance; while its nourishment and

growth are as obscure as if they depended on caprice. Except one,—the French metrical system,—I know no metrology which has a new and independent era of its own, or can point to the register of its birth and baptism. And in this, it may be questioned whether the advantage of historical precision (not to speak of the intrinsics of the system) was not dearly bought in the convulsions of the times that gave it;—whether it is not better to have no baptismal certificate at all, than to have one written, not in ink but blood. In this regard, the English and French systems are as opposite as their coasts.

When, therefore, the troy and avoirdupois weights now established in England, first came there, would be the subject of a fruitless research: they were blending themselves in the commerce of the country from the earliest times of their existence any where. If they did not always show themselves in a distinct recognition as units, they affected the proportionate computation of the heavier commercial weights. The law, for instance, of King Stephen (not now on record, but mentioned by a writer in a time not long subsequent,) *de ansulis*, etc. proves this. The ansula was the steel-yard; called so from the *ansula*, or hook, by which the articles were suspended. Being of Roman origin, it most likely was graduated to weigh by the Roman market-pound, i. e. the present avoirdupois pound, which as seen in the Table was more than a half-ounce heavier than the Saxon pound.

This avoirdupois pound may be what is referred to, in an existing statute of 25 Edward III (A. D. 1351); which says: that the weight, called *aunsell*, shall be altogether abolished, that every one shall buy and sell by *balances*, and that their weights shall be according to the standard of the Exchequer. It is a little curious that a provision, similar in terms, should have been found expedient in Maryland more than three centuries after. This is exemplified in the statute against steel-yards carrying *gross* weight.

The name *avoirdupois*, frequently occurs in the English statutes; but generally as indicative of particular commodities which were sold by weight,—literally *weighable articles*. Its first use, when it may be supposed to refer to a unit of weight,—at least the first that I have found—is in the statute of Stamford, as it is called, dating under 3 Edward II, A. D. 1309. But its influence is manifested in a still earlier statute, to which I have already had reference, denominated an *Assise for Weights and Measures*. This act is placed, in the latest publication of Statutes at large by the Commission for that purpose, very properly among the laws of uncertain date. In some of the earlier collections, part of it is found under 51 Henry III, A. D. 1266, and part under 31 Edward I, A. D. 1303; and it is sometimes referred to by the title of Compositio mensurarum of 1304. Its phraseology shews, however, that it has undergone frequent interpolations, and justifies our

attributing it to some previous time. It rates the pound of money and spices* at 20 solidi (of 12 pence,) the electuary (or medicine) pound at 12 ounces of 20 penny-weights, and the pound for all other articles at 25 solidi or 15 ounces. In so far, it agrees with the prescription in the law of Ethelred the Saxon, before quoted.

In this statute, there are no less than three different *petræ*, or stone-weights, mentioned; one of 12 lb., the London stone of 12.5 lb., and one of 14 lb. These are within a fraction of the proportions of the commercial pounds of Tours, of London, and of 16 troy ounces. The ratio of the two last is as 100 to 112; or precisely our present long hundred-weight. I may state here as the reason for giving in the Table *two* commercial pounds of troy ounces, that, to the

* Upon this, I submit to the learned whether our English word *specie*, as applied to a metallic weight does not arise thus. The statute in the text says: "quelibet lb de deñ et speciebus et confeccionibus, utpote in electuario, constat ex xx solidis," etc. Now *species* in the lower Latinity (*espices* in the old French) meant *spices;* which, with pennies (or money) and medical confections, were weighed by the pound of 20 solidi. Such a pound, therefore, would be equally understood whether it were called the *money* pound or the *specie* pound; and, without a catachresis, the latter title might very well come to predominate over the former.

That this weighing of spices by the money pound was from old time habitual, Pliny has long ago shewn. He says, in regard to the Indian pepper, which grows wild: "— et tamen pondere emitur ut aurum vel argentum;"— not that it was as precious by weight as gold or silver, for if it were as precious as the one it could not be as precious as the other, nor that it was bought by weight, for that was the case with a great many articles besides, but that it was bought by the same weights which were used for weighing gold or silver. See Plin. N. H. lib. xii. c. 14. Tom. iii. p. 10. Ed. Barbou, 1779.

As any thing which relates to *specie*, in the vernacular sense of it, has an intimate connexion with weights and measures, I hope to be excused for this disquisition here.

best of my knowledge, the pound of Troyes never had a market-pound corresponding with it in the place whence it drew its name. It was the pound of the goldsmiths; who devised it for the purposes of gain, and started it at first, as its proportions shew, by adding one-tenth to the Roman pound. By the latter they sold, by the former they bought. In this, they did exactly what the statute-staple (as it is called) of Edward III, in 1353, affirms was being done then; when it says, $\overline{q}$ ascuns marchanz achatent—par un pois et vendent $\overline{p}$ un autre—they bought by one sort of pound and sold by another. But when this bullion-pound came into England, the exchange for it in commercial pounds was regulated according to the previous habits of the different districts where the occasion might arise: the West Saxons took fifteen of its ounces, the Mercians sixteen, to make a market-pound.

So again in this statute, there are two sorts of *sacks;* one of 28 stone, the other of 30 stone. The ratio between these is almost precisely that of the Saxon and the troy 15 ounce pounds. In the time of Edward III, by the statute already referred to regarding the aunsell of 1351, the sack was reckoned at 26 stone of 14 lb. each; in this still retaining the proportion of the troy 15 ounce pound as far as the weight of the stone was concerned; but in the combination for the sacks, adopting a proportion almost identical with that of the Saxon market-pound to the Roman pound.

The computations of hundred-weights are still more various. They are of 100, 108, 110 and 120 pounds. These are very nearly the ratios of the Saxon pound, the troy 15 ounce pound, the troy 16 ounce pound, and that of the troy bullion-pound to the Roman avoirdupois pound.

One phrase in this statute has been supposed to refer expressly to the troy weight. It had given the weight of the chaldron, by one computation, at 175 stone of 12 lb. a piece, making 2100 lb.; it then goes on to give another reckoning by which the chaldron is made to contain 168 stone, adding: et hoc est secundum *Troni* ponderationem. All the translations that I have seen, render this word *Troni* by *Troy;* but it is evident from the numbers, that troy weight has nothing to do with it. I know that the whole passage is faulty, and that it has suffered not only by transcribers but apparently by commentators: yet if, instead of *Troni*, we read *Londi* (and those familiar with the early English manuscripts, will know how easy such a change could have been made by a mere copyist) it will be cleared up. The London weight required 12.5 lb. to the stone; and 168 stone of 12.5 lb. are just equal to 175 of 12 lb. The chaldrons are thus in the two reckonings the same; it would be very singular if they were not: but the text says nothing about the weight of the stone in the second case, because that followed in its being said to be *according to London weight.* This propor-

tion of 168 to 175 is almost exactly that of the Saxon commercial pound to the avoirdupois pound; and indicates the currency of the latter.

We need not, however, resort to this hypothesis of an error in transcription to sustain the interpretation of a London weight if we will admit, with some, the influence (greater than I suppose it ever attained) of the Trojan story to which I just now referred, and which, about the date of this very statute, Geoffry of Monmouth had contributed to resuscitate. According to that, New Troy or Troy-novant is the synonym of London. It is fair to say, nevertheless, that the advocates upon this fiction make quite a different application of it. For instance, Davies Gilbert—one of the Weight and Measure Commission of 1818 by which the present English standards were fixed, and one of the successors of that very President of the Royal Society who re-discovered and proved the Saxon pound—believes (not the legend of Brutus, of course, but) the troy pound to be the old London pound from the time of Edward the Confessor; and he quotes the synonym as proof. But the fact is, that this piece of heraldry was quite extinct in the time of the Confessor; it had been faded for two hundred years before, and was not begun to be re-blazoned for nearly as long a period afterwards.

The troy pound is, however, specifically mentioned, very little more than a century later than the statute

just now quoted, in one of 2 Henry V; and a few years after, that again in one of 2 Henry VI; the last of which even determines its value. It rates silver plate and bullion of sterling alloy at 30 shillings the pound troy, besides the fashion if it is in piece; saying, that its value as coin was no more than 32 shillings. Now, ever since the thirteenth year of Henry IV, the Tower pound had been coined into thirty shillings; and if the troy pound was worth thirty-two, their proportions must have been as 30 to 32, or as 15 to 16, which is precisely the proportion given in the verdict establishing the troy pound at the mint.

Troy weight is again mentioned by the statute 12 Henry VII, of which I have already spoken, and which is referred to in our Maryland act of 1671. It is there used, along with the Roman avoirdupois weight, for the combinations of the new capacity-standards of 1496. Some of the English writers have supposed, that it was also at this epoch introduced into the mint; but this is only an inference. Against this, are both the existing coins and the express adoption of the troy weight at the mint in 1526. From this last date, the English nummulary and commercial pounds have been troy and avoirdupois, very nearly as they are now.

The existing English statutes shew that in the reign of Edward III, brass standards, both of Weight and Capacity-measure, were made and distributed by

public authority; the Exchequer contained, at one time, some standards supposed to be older than those. The linear measure of Henry VII, and his capacity-measures under the laws of 1494 and 1496, have been already mentioned. But in 1743, when Mr. Graham's examination was made, there were no standard-weights that could be dated higher than the age of Queen Elizabeth. Taking these as the standard of comparison, the results were as under:

	Troy Pound in Troy grains.	Avoirdupois Pound in Troy grains.	Date of Standards.
Exchequer, 12 ounces:	5760.000	7000.1375	about 1588.
Founders' Company:	5761.750	7001.0150	marked 1684.
Mint, 12 ounces:	5761.875	.	do. 1707.
Mint pound:	5760.125	.	used in 1742.

The comparisons of Sir George Shuckburgh were made principally with a view to deriving a unit of Weight; which he, as Whitehurst had before him, proposed to find in a cubic inch of distilled water. He did not therefore examine the old standards; but compared the weights made for him by Mr. Troughton, with those that had been made by Bird with Harris the assay-master of the mint, and reported to the House of Commons by the Committee of 1758. There were four of these; a one-pound and two-pound weight, in duplicate, resulting as under:

Troughton's lb.	Parliamentary Mean 1 lb.	Mean 2 lbs.
5760 grains.	5763.715 grains.	5763.850 grains.

The weight which he assigned to a cubic inch of

water, was expressed in grains; each of which was $\frac{1}{5760}$ of the mean of the Parliamentary standards.

When the Commission of 1818 came to revise his observations, they were found substantially so accurate as to justify an adherence to them; which their acceptation, for five and twenty years among the learned in Continental Europe, rendered besides so desirable. And as the Parliamentary one-pound weight (called A. 1758) an existing unit, differed the least from the mean result, it was recommended by the Commissioners and adopted by the Legislature as the "unit or only standard measure of weight from which all other weights shall be derived" under the name of "the Imperial Standard Troy Pound." The avoirdupois pound was derived from this standard by the ratio, which the experiments of Graham shew to have been habitual for two hundred and fifty years at least, viz: that of 7000 grains to 5760 grains.

The test of value for these grains is supposed to rest upon a permanent and universal natural law—the gravitation of distilled water at a certain temperature and under a certain atmospheric pressure. And the value itself is such, that 252.458 brass grains (but of specific gravity undefined) will be in just equilibrium with a cubic inch of distilled water, the mercury in a barometer standing at 30 inches and in the thermometer of Fahrenheit at 62°, both for the air and for the water. In testing or recovering the

value of the inch, should that be the question, it is presumed to be such as is contained 39.13929 times in the length of a pendulum that, in a vacuum and at the level of mid-tide under the latitude of London, vibrates seconds of mean time. I have already spoken of the theory of this; I will only add that the precise reproduction of the inch or of the unit of weight, by observation of the natural phenomena with which they have been connected, would be a problem requiring the highest and most successful efforts of Science and Art combined.

3°. *Measures of Capacity.*

The connection, from the most ancient times, between Liquid and Dry Measures authorizes them to be treated together; and their reciprocity, which is a marked feature in the Saxon system, renders such a treatment here peculiarly necessary. I therefore make but one class of both.

So great was this reciprocity, that even the names of some measures came to be interchanged; for example, the gallon—a word originally applicable to liquids only, and a vessel which, when filled with wine, was the eighth part by *weight* of the bushel of wheat—was employed to signify also a very different measure, the eighth part by *volume* of the bushel; explanatory epithets distinguishing them were not alway added; and to this may be traced in part the

confusion enveloping the former capacity-standards in England, and the final step there of doing away with them altogether. The very beauty of the system increased its fragility and contributed to its decay. A similar instance might be alleged from several of the other denominations; the bushel only, which means primarily a textile fabric, has been uniformly held to its signification as a unit of dry-measure. Both of these terms—gallon and bushel—are found in the lower Latinity, before they were borrowed by the Saxons in Britain.

In proportioning at first the measures for substances in drops and in grains respectively, the simple idea seems to have been—*equiponderance.* The vintner and the corn-grower, for instance, although their transactions were made by measure, in reality interchanged their commodities by weight; the corresponding measures of wine and wheat, although of very different magnitudes, yet contained the same number of pounds. For any one article, the magnitude of the unit of measure is determinable by the multiplication of linear dimension, though even in such case the easiest and most practical method of estimating or comparing magnitudes is by weight of their contents: but in making transitions among capacity-measures for different articles, it is absolutely necessary to resort to weighing in some part of the process. And as commerce gradually increased and a greater number of articles came to be offered in

market, the constant reciprocity between magnitude and weight would come also to be more fully acknowledged and applied. Any vessel, after its contents of different articles had been once weighed, would serve either as a capacity-measure for any, or, filled with one, as a weight itself to balance against all others. Thus as between wheat and wine, a vessel first constructed by linear rules to be a certain part of a cubic foot, and found afterwards to contain twelve ounces of wheat, would be found then to contain fifteen or sixteen ounces of wine. According as it contained one or the other, it would be a weight or pound of twelve ounces or of fifteen or sixteen ounces; as determinate in theory, as if it were of metal itself, and more universally applicable in early times, when all metal was too precious to be kept merely as a means for counterpoising. In such application is easy to be seen the origin, both in value and denomination, of the *commercial* pound.

All this is exemplified in the English system, as it had been before in the establishments of other countries. The earliest English law expressly on the subject—the *Assise for Weights and Measures*—which I have before spoken of, and which certainly antedates the fourteenth century, reads (when translated) as follows:

"By ordinance of the whole realm of England, has been established the measure of our lord the King; to wit: that the English penny which is

called sterling, round and without clipping, shall weigh 32 grains of corn in the middle of the ear;
and the ounce should weigh 20 pennies:
and 12 ounces make the London pound:
and 8 pounds make the gallon of wine:
and 8 gallons of wine make the London bushel:
and 8 bushels make the London quarter."

It then goes on with various reckonings by *sacks*, *stones*, and *hundreds*, and winds up with a note on the distinctions between the specie pound of 12 ounces and the pound "for all other things" of 15 ounces—particulars, to which I have already referred in speaking of the measures of weight.

The terms of this law point plainly to its parentage. It is a rifaccimento of the two systems most extensively recognized in Europe; and some of its proportions go up to the epoch when linear measures of capacity preceded weights. To take these terms in order: the proportion of the penny sterling to the grains of wheat is that of the Roman mint and commercial pounds. There is no direct proof, as I said before, that the Saxon penny-weight was divided into grains; nor is there, that I am aware of, any precise knowledge as to the date when the troy penny-weight came to be counted in grains, either. Both, no doubt, conformed to the Roman reckoning of 24 lentes to the scriptulum or *scruple*. This proportion of 24 to 32 (or of 12 to 16) answered very well with the wheat of Italy; but did not correspond

in the case of the lighter wheat of Gaul, which the Roman settlers introduced into Britain, and which the troubles of the Octarchy kept as an article of commercial import long after the earliest Saxon times. The introduction of a new pound served, therefore, as the occasion for making the correction due to the actual correlative weights of the wine and wheat brought to the British market: and this correction was made, in taking a commercial pound of 15 ounces. But the old ratio was still left in the count; because, as with the length measures, the number of grains of corn was only an indication, not a constituent, of the unit; the standard of the whole system exposed in the law just given, was the silver penny, of which 240 went to the sterling or London pound. The disappointment, therefore, of some observers in the early part of the 18th century, who could not get 32 grains of wheat to weigh 24 metallic (then, troy) grains, and the gratulation of others who could, belong more to the question of patriotism than of accuracy in either physical or historical lore.

How 20 sterling pennies came to constitute the ounce, I have already explained; and the reckoning of 12 ounces to the pound, ascends to times long anterior to what I have taken as limiting the view of this Report. This duodecimal count, as well as the frequent recurrence of the multiples by 8, both mark the Greek period; when a people, subtle in arithmetic, had perceived and applied the abstract rela-

tions of numbers. It would be curious to point out, did my space and object allow, the varied harmonies observable in this very statute; it is enough, however, to say that the number 12 was chosen, because it is the sum of all the aliquot parts (including unity as a divisor) of the first perfect number, or, more popularly, it is divisible into more whole factors than any other number, not a multiple of it. The adoption of 8, as a multiple and divisor was peculiarly appropriate in capacity or cubic measures; because it is the first perfect cube in the decimal series. Hence it was that, in all the elder systems of measures, the liquid gallon was, in dimension, $\frac{1}{8}$ of the cubic foot: and there can be little doubt that it was so still at the time of the origination, if not the passage, of this law.

It is true that the phrase itself of the law does not determine the wine-gallon otherwise than by weight: but even thus, an indirect valuation may be deduced for it in linear measure. The 8 pounds, which were to make the gallon of wine, were not nummulary pounds but, as is plain from the special note in the statute, commercial pounds; *wine* was among the "all other things" weighed by the pound of 15 ounces. Now, 8 pounds of 15 ounces are 120 ounces sterling; and the sterling ounce being $\frac{1}{16}$ lighter than the troy ounce, 8 sterling pounds are equivalent to 112.5 troy ounces or 54000 troy grains. The weight of Gascony or Bourdeaux wine, repeat-

edly referred to by name in the English statutes of the period during which the district was an appanage of the English crown, and therefore fairly presumable to have been intended in this, is very nearly (according to the latest determination of the weight of water, and exactly, according to some former observations) 250 troy grains to the cubic inch; which gives precisely ($\frac{54000}{250}$ =) 216 cubic inches to the gallon, or $\frac{1}{8}$ of the cubic foot.

Farther, these 54000 grains are just 10 Saxon mint-pounds. I have already noticed, in speaking of the Roman capacity-measures, the coincidence between the congius and the English gallon—both being of the weight of 10 money-pounds: and I notice this weight again to remark that, with the proportions of 12 and 15 ounces to constitute the wheat and wine pounds respectively, the vessel which contained 10 pounds of wine would hold just 8 pounds of wheat. In fact, some of the older editions of the English statutes have in this very place supplied the words, so as to make it read "8 pounds of wheat make the gallon of wine." Such an alteration, although it makes the deductions no clearer, renders the passage more symmetrical: it keeps the pounds to the computation of 12 ounces apiece; and, combining throughout the proportionate specific gravities of the two staples, it ascends from the weight of wheat to the measure of wine and thence again crosses over from the weight of the gallon of wine to the measure

of the bushel of wheat. With or without this addition, however, the statute finally weighs the bushel and makes it $\frac{1}{32}$ of the ton.

Such is the analysis of this statute. Under it and under the old laws which it was intended to re-enact, the gallon of wine was in dimensions 216 cubic inches, or a cube whose side was 6 inches—the inch being almost or perfectly identical with its value at the present day; and the bushel must have been, (accepting the proportions of the 12 and 15 ounce pounds as the ratio of the specific weights of wine and wheat,) in dimension 2160 inches, or such a vessel as filled with wheat would counterbalance a cubic foot of wine, the tare being the same in both cases. There is no wine-gallon remaining of exactly this size: but the Irish gallon,—which we may presume to have been in accordance with this law; which remained, till twenty years ago, unaffected by the reformations of the English standards; and by which the excellent wine of Bourdeaux, that one meets with in that island, is yet measured,—is of 217.6 cubic inches. So small a difference may warrant the supposition, that the one was made for the other. If the vessel were a cylinder of the proportions subsequently defined in the first act prescribing a wine gallon by linear measure, an excess in height by $\frac{1}{25}$ of an inch, above what was due under a constant pressure and temperature to 216 cubic inches, would give rise to the Irish gallon. And so with the

bushel, a similar variation (but in the contrary sense) by $\frac{1}{20}$ of an inch, would have produced the old Winchester bushel of the Exchequer, of 2145.6 cubic inches. Those who are familiar with the artistical manipulation necessary for capacity-standards at the present day, can best judge how likely would have been at that period, such variations.

One might therefore plausibly maintain, if so inclined, that the so-called Winchester bushel, actually executed in the time of Henry VII and found about two centuries later to contain 2145.6 cubic inches, failed, either by its own error or by the degradation of the standard from which it was copied, to give the just content of 2160 inches aimed at by this or older statutes. And such an opinion would not be precluded entirely, by the fact of there having been, at the time of the execution of this copy, a standard in the Exchequer much smaller, (2124 inches) dating as of the period of the first successor of the Conqueror: for the difference between the two, coupled with the name of the former, would indicate for its original an age before the Norman settlement, when, as under Edward the Confessor, Winchester was the capital of the kingdom.

I do not, however, myself mean to sustain this opinion. The name of Winchester was recognized for this standard in 1670, under Charles II, (for the first time by any English law as far as I am aware, although our Maryland Act had so termed it, thirty

years before); it is rather an excess of research to trace its title, as some have done, to the statute of Winchester, under Richard II; and I think, finally, that I shall shew directly a much more natural and direct origination of this bushel of 2145.6 inches, though as long as the proportional gravities of wheat and wine remained uncorrected as being 8 to 10, the bushel of 2160 inches undoubtedly belonged to the undeniable wine-gallon, that was $\frac{1}{8}$ of the cubic foot.

It is hopeless to look for this correction any where but in the statutes themselves. We may arbitrarily assume it, as some have done, to have been manifested in the substitution of the troy and avoirdupois pounds for the old sterling and 15 ounce pounds: but what has been said already in this Report will shew, I think, that the troy and avoirdupois pounds have in reality nothing to do with it; different in the place of their origin and in the epochs of their acceptation, coming in gradually with the articles and phrases of foreign commerce, they could not represent the proportionate gravities of substances, one of which was, at the time of the statute under consideration, extensively grown in Britain. We must admit an instance of most extraordinary balance of errors, or an example of sagacity more than human, if we suppose that the English lawgivers, abandoning their own old Easterling weights and going to one climate for a new nummulary pound, had selected from another a new commercial weight, be-

cause these two new weights would represent in England,—what neither was calculated to do any where else,—the specific gravities of wheat and water, respectively. And we have then to admit besides that the new proportions, so logically composed, do not after all represent the specific gravities of wheat and *wine*, which is the very point in question.

If, leaving this mode, we resort to actual experiment and seek to retrace the steps our ancestors might have pursued, we find an issue hardly less vague. I need not stop to point out the causes of such vagueness, nor why it is unavoidable: I shall merely throw together in a tabular form the chief results which philosophers have sanctioned or which, as part of national establishment, remain to be quoted at this day.

	Weight under equal Volumes Wheat.	Wine.
Roman proportion of 12 to 16 oz. . .	144.	192.
Pliny's account of Gallic wheat, . . .	144.	186.88
Saxon proportion of 24 to 32 grains, . .	144.	192.
Saxon proportion of 12 to 15 oz., . . .	144.	180.
Sir Jonas Moore's Experiment on British wheat,	144.	199.32
Oxford Phil. Soc. Experiment in 1685, . .	144.	185.21
Exp't on the bushel of 2145.6 inches in 1696,	144.	177.55
Troy and avoirdupois proportion in Arbuthnot,	144.	174.86
Troy and avoirdupois proportion, . . .	144.	175.
President J. Q. Adams' deduction, 143 : 175 or	144.	176.22
Standard wheat in Maryland, ...	144.	184.32

The wine in this table is rated throughout at 250 grains troy per cubic inch.

It is apparent from this that observations, on a small scale at least, lead to no accordant or useful result; and to open the combinations of reasoning or error which have produced wine gallons from 217.6 to 231 cubic inches and bushels from 2124 to 2224 cubic inches, we must find a key somewhere else.

In fact, a statute of 2 Henry VI, A. D. 1423, which, like the one we have just come from, professes to exemplify the ordinances "of old time," does unlock all the difficulty: by it, the shipping unit—the ton—in which both liquid and dry capacity-measures finally merge, and which by the so-called Act of 1266 had been applied to the measure of wheat, is here extended and applied to the measure of wine. It prescribes, as the old assise of the ton, that

the tun of Gascoigne wine should be 252 gallons
the pipe . . 126 gallons
the hogshead . . 63 gallons.

Now, comparing the two assises together, we find the hogshead of wine equiponderant with the quarter of wheat; four of either constituted a ton, or tun, of shipping. But if we keep to the ratio of the 12 and 15 ounce pounds and apply the terms given in the assise of 1266, we must make the hogshead (not of 63 but) of 64 gallons: such being the number of corn-gallons in the quarter of wheat. The proportionate difference between these two numbers is the discount which our ancestors, not in 1423 only nor in 1353 (when, by another statute, this assise of the

tun is also referred to,) but in both these years as "of old time," found necessary to make upon the commercial pound of 15 ounces, in order to have the physical equiponderance which both the symmetry of the system and the balance sheet of the merchant required. This discount results in a commercial pound of $(\frac{63}{64} \cdot 15 =)$ 14.765625 ounces; and for specific weights of wheat and wine, in the ratio of 144 to 177.1875.

This will be perfectly plain, if any one will take the trouble to tabulate all the results of the several factors in the two systematic developements of these two statutes. I shall present here an extract from such a tabulation.

Wheat System or Nummulary Reckoning.

Ton.	Quarter.	Bushel.	Gallon.	lb.	oz.	dwt.	grains of Wheat.
1	4	32	256	2048	24576	491520	15728640
1	4	—	252	2016	30240	604800	19353600
Tun.	Hhd.		Gallon.	lb.	oz.	dwt.	grains of Wheat.

Wine System or Commercial Reckoning.

The numbers expressive of gallons and pounds in this table require to be applied inversely to 15 ounces, to give the rational commercial pound; while those from the ounces inclusive, are directly in the proportion of the relative gravities of wheat and wine. All lead to the same numerical result.

It makes no difference, whether this proportion was accepted from caprice or by trial; from its near accord with the experiment of 1696 given in the table, it was most probably from the latter. Nor is it

even of moment whether it is the *true* proportion, in the sense of a universal natural law; such as has been imagined and eloquently insisted on by a distinguished writer upon the subject in our own country. The simple question is: what was the adopted proportion?—and to this, the statutes return, I think, a straight and decisive answer. That the answer should not have been listened to before, is of no importance.

With this recognized proportion, we may now proceed to the exposition of the various liquid and dry standards which have been constructed at different epochs; and shew how the discrepancies, which I have already alluded to, had their rise. I may remark first, however, that such capacity-*measures* are with propriety so named: they originated primarily from linear measures, although determined correlatively by weight. The common unit was the foot; the half-foot cubed gave the content of the liquid gallon, which would hold also 8 money-pounds of grain; and corresponding was the corn-gallon (unfortunately termed so) as much larger than the wine-gallon as 177.1875 is greater than 144, and intended to hold likewise 8 commercial pounds of wine. But the corn-gallon, filled with wheat, and the wine-gallon, filled with wine, were equiponderant.

Similarly equiponderant were to be the contents in wine of the unitary foot when cubed, and the contents in wheat of the bushel, whose volume was to

that of the cubic foot as 177.1875 to 144; all the relations of the bushel to the cubic foot were similar to those of the corn to the wine-gallon; and as the cube of a foot is 8 times that of the half-foot, so the capacity of the bushel is 8 times that of the corn-gallon.

I need not go through the elementary transformations of these numerical data; it is sufficient to present the results. The wine-gallon of 216 inches thus gives a corn-gallon of 265.78 and a bushel of 2126.25 cubic inches. The bushel in the Exchequer, marked 1091, and now deriving fresh support for that as the true date, was 2124 inches; and the Rumford corn-gallon of 1228, contains 266.25 inches. The Rumford quart gives 264.8 inches; and the mean of the two a gallon of 265.53 inches. Such differences, assuming absolute accuracy in the workmanship, are positively within the influence of temperature at opposite seasons of the year.

Compared with the gallon of 216 inches, the Irish gallon of 217.6 is without the limits of temperature; and we must suppose either that an allowable error occurred in the workmanship of the standard, or that there was a designed correction of the old Roman assumption of water and wine being equiponderant. Taking the specific weight of water as 1. and the gallon of water at 216 inches, the Oxford experiment in 1685, which found for claret or Gascoigne wine a specific gravity of 0.993, would re-affirm the possi-

ble observations made before 1266 and result in an equiponderant wine-gallon of 217.52 inches. But however this may be, the actual new unit of 217.6 inches corresponds, upon the preceding data, to a corn-gallon of 267.75 and a bushel of 2142 cubic inches. Such a corn-gallon is rather larger than even the Rumford gallon and indicates therefore the anomaly of the wine-measure unit. But the bushel is no doubt the original of the Winchester bushel; which I take to have been introduced by the Third Henry, surnamed of Winchester, and to have been thus denominated to distinguish it from the other and smaller Rumford measure before in use.

Such was the state of the capacity standards, down to nearly the close of the fifteenth century, under Henry VII. In the seventh year of this Prince (in 1491) an act of the Commons requested that standards might be made, for distribution to the counties, conformable to these in the Exchequer; and again in 1495, a statute directed their construction, and closes with a schedule of forty-three county-towns in which such standards are to be deposited. It gives no prescription as to the assise, farther than that there should be "8 bushels raised and stricken to the quarter of corn; 14 pounds to the stone of wool; and 26 stone to the sack." But in the very next year, 1496, another statute, after referring to the preceding and to its actual execution, recites that the weights and measures made under it, "upon more diligent exam-

ination had synz the making of said statute, proved defective and not made according to the old laws and statutes thereof ordeyned within the said realm: Wherefore" it goes on to enact—"that the measure of every bushel contain 8 gallons of whete;

every gallon 8 pounds of whete, troi wt.;
every pound 12 unces of troi weight;
every unce 20 sterlings; and

every sterling be of the weight of 32 cornes of whete that grow in the middes of the eare of whete, according to the old laws of this land." It directs, then, that all these erroneous measures be sent back "to be broken, and with the stuff and metal of the same—other new ones be made."

This is the statute referred to in our Maryland Act of 1671; and of which I have already said, that it legalized neither the Winchester bushel nor the habitual wine-gallon of the Province. The Winchester bushel can by no contrivance be made out of it: the Maryland wine-gallon, which contained then (as now) 231 cubic inches, does indeed flow from it, if when it says "gallons of wheat," one supposes it meant gallons of wine: but such a gallon was not legalized by it, for none such was made under it. The wine-gallon of 231 inches was first made legal more than two centuries later (in 1706) by the statute of 6 Anne; although the popular opinion, both in England and in Maryland for a long time antecedent, had been that such was the true intended size

of the gallon. I incline to think that no wine-gallon was made immediately upon this Act.

For in the Exchequer in 1688, when an inquiry was instituted in regard to the Excise, there appears to have been no wine-gallon at all; only corn-gallons. And the wine-gallon at Guildhall, by which the guaging of liquors in the port of London was regulated and which was currently estimated to hold 231, the Excise-commissioners found to contain but 224 inches. This Guildhall gallon was therefore most probably made under the former statute of 1495, and thus may have contributed to those errors which, more flagrant in the larger measures, induced in 1496 the recall of the latter. Why it was not recalled itself, can now only be conjectured.

The terms of the law of 1495, indicate how the gallon of 224 inches grew out of the old gallon of 216 inches. By that law, the sack of wool was to be 26 stone, and the stone, 14 pounds; so that the sack weighed 364 pounds. By the old laws of the land, the sack was to weigh but 350 pounds. These two different weights are, as I before observed, in the proportion of the Saxon commercial pound (of 6750 grains) and the Roman avoirdupois pound (of 7000 grains); and this proportion inversely is almost exactly that of the gallons of 224 and 216 inches. The artists of Henry VII must have weighed by the avoirdupois pound instead of the old easterling 15 ounces. Such a wine-gallon, raised by the constant proportion

which I have given before as maintained between the gravities of wine and wheat, would give a corn-gallon of 275.625 inches and a bushel of 2205 inches: if the ratio of 350 to 364 were used, it would give a corn-gallon of 276.41 and a bushel of 2211.28 inches;—neither of them very materially differing from the Exchequer gallon of Henry VII, of 272, and the bushel of the same monarch, of 2224 inches.

These last standards, however, were most likely made under the following Act of 1496. As they had used avoirdupois weight in the construction of the wine-gallon of 224 inches, and as the law now required troy weight to be employed for the wheat pounds, we may date here the dereliction and final loss of the old ratio of weight between wine and wheat (viz: as 144 to 177.1875) and the adoption of a new one, the ratio between troy and avoirdupois, viz: as 144 to 175. Using this last ratio, the corn-gallon corresponding to the wine-gallon of 224 inches would be 272.22 inches; almost identical with the gallon of Henry VII. A gallon of 272.25 inches is the one used by Arbuthnot in his Tables; and, forty years ago, was actually legalized by act of Parliament.

But this gallon would make a bushel of 2177.78 cubic inches; which corresponds with no existing standard, and is very far from the Winchester bushel, copied by Henry VII and accepted long before the

accession of the House of Hanover. If then in the time of George III, such discrepancies could be admitted, we are authorized to tolerate their occurrence in that of Henry VII and to trace his bushel of 2224 inches from a wine-gallon of 230.4 inches, by the same proportion of troy and avoirdupois weights.

Troy weight was, we know, one-fifteenth heavier than the old sterling weight; and equivalent volumes weighed by the former must be sixteen-fifteenths of those weighed by the latter. Thus a volume of 216 cubic inches, weighed in old sterling, and a volume of 230.4 inches, weighed in troy, will shew the same weight in the different denominations. A wine-gallon of this last content, raised by the wine and wheat proportion of the old laws of the land, gives a corn-gallon of 283.5 and a bushel of 2268 cubic inches; raised in the new proportion of troy to avoirdupois, its corn-gallon is 280 and its bushel 2240 inches. This last was the aim nearly attained by the large bushel of Henry VII; and the gallon of 280 inches was exactly reproduced by the standard of 1601 in the Exchequer. The small bushel of Henry VII of 2124 inches, was a copy from and identical with the old Rufus bushel; and his Winchester bushel of 2145.6, intended for the Irish bushel of 2142 cubic inches.

That the phrase in the law of 1496—"the *measure* of the bushel"—should be interpreted, like some have done, as if the English law-makers of that

epoch forgot or misunderstood the idea of equiponderance to which their people had been habituated for nearly a thousand years, and meant to substitute *measure* for weight, hardly follows, even grammatically: it is disproved in fact, by the existence of the corn-gallon of 272 inches, which cannot be made out otherwise than by weight. Computed by measure alone, the wine and corn-gallons would have been of the same capacity, viz: 224 or 230.4 cubic inches, and the bushel of 1792 or 1843.2 inches; a shocking violation of the habits of the people, which did not need to have been inflicted in forty-three different places before it made itself felt, but would have reacted, before the standards that exemplified it had left the purlieus of the Tower. The legislators of 1496, to be sure, did not appreciate the symmetry of their early system, or they never would have engrafted, without a salvo, troy weight upon sterling; and those who executed their laws may have appreciated it as little and understood it less, or they never would have made three different bushels (and so different) in the search after uniformity: but neither were so steeped in error as to presume and to act upon the presumption, that wine and wheat were of the same weight. Finally, the phrase of the law of 1496 is, as far as possible, and its numerical quantities exactly, the same with the old laws which it was intended to renovate. The radical mistake, only, was what had originated two centuries before

under the first Norman Edward, had been going on ever since, and reached its climax in height though not all its developement in extent and variety, now. This was the non-conformity between weights and coin: and this made the old laws speak a language hard to be understood, because the things were no longer existing which their words expressed.

From this time, the end of the fifteenth century, until the beginning of the seventeenth century, no new standards appear to have been made by any public authority; the capacity-measures of Elizabeth, like the linear ones, replace those of Henry VII. The law of 1496 did not expressly mention any gallon for wine: but I have already shewn how the habitual popular interpretation must have demanded one, and how it came in the immediate execution of that law to be 224 cubic inches, and in subsequent theory to be 230.4 inches. This last value gave rise to some of the standards of 1601. Of this date, there are gallons of 270.4 and 271 inches; a quart and pint belonging to gallons of 280 and 278.4 inches, respectively; and a bushel of 2128.9 cubic inches. The gallons were copies of the Henry VII corn-gallon; and the bushel, of the same Prince's small one of 2124 inches, which was itself identical with the most ancient standard. The quart and pint were made upon the gallon for wine of 230.4 inches, augmented in the proportion of 5760 to 7000 for the corn-gallon. Such an augmentation gives a content of exactly 280 inches.

This wine-gallon of 230.4 inches was never positively executed; it existed only as an arithmetical deduction from the number of inches in the eighth part of a cubic foot, and therefore might very well for ease of remembrance be taken in round numbers as 231 inches. In point of fact, the round number is exactly divisible by 7; and a cylinder of 7 inches in diameter and 6 inches in height, is almost exact in the content. Such was the guage actually adopted about a century later, when the gallon itself was made the subject of a statute. I may remark here, that it was the estimate of 231 inches for the wine-gallon and the positive corn-gallon of 280 inches, which produced the ratio of 14 to 17, for a long time accepted between the troy and avoirdupois weights. The comparison of other standards afterwards, (about a century ago) modified this into a proportion of 14 to 17.5, and at length into 144 to 175 identical with 5760 to 7000 grains.

That the count of 231 inches was current before the time of the Elizabethan standards, is indirectly proved by a statute of the same reign (13 Eliz. A. D. 1570) relating to the herring-fishery. It appears that informations had been laid against the herring-barrels, which had been usually guaged and allowed in London at 32 gallons wine-measure, for not containing 32 gallons corn, or rather *ale*-measure; and this information was founded, 1°. upon there being no wine-gallon in the Exchequer, the depository of the

legal standards, but (as I said before) only corn-gallons; 2°. upon a statute of Henry VIII, five and thirty years before, which required the coopers to make barrels for ale to contain 32 gallons, corn-measure; and 3°. upon "the extremity of old statutes in words by some men's construction," as the Act itself expresses it, coupled with an indignant denial. To quash these informations and preserve the herring-fishery from disturbance, the Act summarily declares, that "thirty-two gallons wine-measure, which is about twenty-eight gallons by *old standard*, shall be the lawful assize of herring-barrels, any old statute to the contrary notwithstanding." The ratio of 32 to 28 is very nearly that of the corn-gallon, derived from the sub-octave of the cubic foot, and exhibited in the Rumford standards of the Exchequer, to a gallon of 231 inches: so that the *old standard* of the law must have been these Rumford measures, and the habitual wine-measure must have been recognized at 231 inches. The *old statute* referred to, was doubtless the earliest Assise for weights and measures of 1266 (so-called); whose details I have already given.

We may see here a fresh developement of the misunderstanding of the Saxon system of measures, that was exhibited by the act of 1496: a misunderstanding which, although plain enough to us now, the phrase of the Assise of 1266 and the singular symmetry and correlation of its terms contributed to

foster. When that Assise says that "eight gallons of wine make the London bushel," the legislators under Elizabeth seem to have read it as if by volume, not by weight; the gallon *of* wine and the gallon *for* wine, they held as synonymous; and as they found no other ancient gallon in the Exchequer but the Rumford measure, which was in volume the eighth part of the bushel of William Rufus, they naturally concluded that to be the *old standard* and termed it so accordingly. How or why there should be a newer smaller standard for wine, they do not, at this session at least, appear to have known: had they known, the occasion was every way proper for the exposition.

It is clear that the knowledge on the subject did not increase during the following century. For all that time, no actual standards had been made; and several statutes that were enacted, confined themselves to the enforcement of the measures already existing. One of 22 Car. II; A. D. 1670, prescribing by name the Winchester bushel of the Exchequer, I have already referred to. In 1688, the Excise-commissioners desired to learn why there was one gallon for wine and another for beer; and it was upon this enquiry that the Guildhall gallon was guaged to contain 224 inches, which, although there was reported to have been an Exchequer gallon of 231 inches, they found reason to conclude was the true wine-gallon. Three gallons in the Exchequer (one of

Henry VII, and two of Elizabeth) were found to contain 272 inches. Other standards, which I have already mentioned and which were measured upon a later and more exact inquiry, do not appear to have been examined. As beer and ale were liquids as well as wine, and as the excise-revenue would be augmented by taxing on a smaller gallon, they proposed to adopt the Guildhall measure throughout. But difficulties being of course made by those who had to pay the duties, and the opinion of the attorney-general being solicited in the matter, that officer, after an examination of the statutes, said: that he did not know how the 231 inches came to be taken up, inasmuch as there was no positive standard of that size; that the smaller gallon at Guildhall would not be maintained as a legal standard by the courts; that the larger gallons of 272 inches, if adopted throughout, would cause a vast loss to the revenue; and finally that it was safer to adhere to the usage. This opinion terminated the question for the time.

In 1696, under William III, an act of Parliament declared, that "every round bushel with a plain and even bottom, being 18.5 inches wide throughout and 8 inches deep, shall be esteemed a legal Winchester bushel according to the standard in His Majesty's Exchequer." The actual Winchester bushel in the Exchequer had been found at this time to contain 2145.6 inches: and the dimensions adopted in the statute were intended to come as nearly as possible

to that capacity, without resorting to small fractions. It was therefore, like the count of 231 inches for the wine-gallon, a compromise for convenience. But it destroyed both the symmetry and the principle of dry measures, in introducing a new and arbitrary method of computation by cubic inches instead of pounds. The same method was very shortly after applied also to the liquid measures.

This was the more to be regretted, because they were at this time upon the verge of discovering the proportions and reasonableness of their earlier standards; they had indeed the key in their hand already. The Oxford experiment in 1685, which I have referred to in the table just now, had made a cubic foot of pump-water to weigh 1000 ounces avoirdupois; and the trial in 1696, which I have also quoted in the same place, shewed the Winchester bushel of wheat to weigh 1000 ounces avoirdupois, too. The ratio from this last gives almost identically the same factor for wine and wheat weights, which is furnished by the old Assise of the tun; and had they gone on to guage the Rumford measures and the Irish gallon, they would have found at every step most satisfactory coincidences with the ancient laws that Sir Thomas Powis had in vain otherwise tried to reconcile. But having long lost all coincidence in their coin, (for although the English money was still called *sterling*, it bore no relation to the *easterling* pound) they lacked encouragement in the

very first step; they took the gallon of wine to be a phrase as antiquated and vague as the penny sterling; and this novel and accidental coincidence between the cubic foot of water and an inaccurate bushel of wheat, drove them still farther astray. All the speculations of the period laboured to explain, by the avoirdupois weight of water, a system which was founded upon the easterling weight of wine.

In 1700, occurred a new case for inquiry in which the attorney-general again figured; but not more successfully now in the forum than before in his chamber. A merchant had paid duties on sixty butts of Alicant wine at the rate of 126 gallons the butt; but the guaging had been by the reputed capacity for the ale-gallon of 282 inches, instead of the actual Guildhall wine-gallon of 224 or the reputed wine-gallon of 231 inches. I call this the *reputed* capacity; because although the positive standard at the Treasury was admitted by both parties to contain 282 inches, and such was very likely its accurate content, yet such a capacity had not been intended when the standard was made, nor does it conform to any possible theoretical aim. When made for the Treasury or removed there from the Exchequer, either it was copied from the gallon of 280 inches of 1601, or from the large gallon of Henry VII, which should have been of 283.5 inches; or it was founded upon the $\frac{\text{avoirdupois}}{\text{troy}}$ ratio, multiplied into the reputed wine-gallon of 231 inches. Such a ratio and mul-

tiplication would give dimensions of 280.73 inches. Or, finally, it may have been intended to have been made as much larger than the earliest Rumford measures as the admitted wine-gallon of 231 inches was larger than the Irish gallon; which, both being of remote antiquity, were very properly suspected to be somehow connected together. This computation gives a content of 281.85 inches. However derived, the round numbers must have been, like the wine-gallon itself and the Winchester bushel, a compromise for the convenience of linear guaging.

When the case was tried, the Crown proved: 1°. that by the old Assise of the tun and subsequent statutes, the butt ought to contain 126 gallons; 2°. that by agreement of all the guagers, a wine-gallon was of 231 inches,—which content they all ascribed to the Guildhall gallon, though it does not appear to have been re-measured since 1688; 3°. that the Exchequer gallons of 272 inches were for corn only, and the Treasury gallon of 282, specially for beer and ale. The defendant, Barker, proved: 1°. that the 126 gallons of the old Assise referred to Bourdeaux wine, and that as far back as 1327, at least, a statute of Richard III admitted the Spanish wines in butts of 140 gallons; 2°. that by the agreement of all the dealers, his butts were of the size that had been habitual as long as any one could recollect; 3°. that by the standard kept at the Treasury, as the law required, he had paid the duty, and that with the dis-

tinctions of wine, corn, and ale gallons, he had no concern. Upon this, the suit was given up: but the advice of the attorney-general that Parliament should remedy the matter, was followed; and shortly after was passed the statute of 6 Anne (A. D. 1706) by which the gallon for wine was fixed (following the example of the Winchester bushel) by declaring it to be any uniform cylinder of 7 inches diameter and 6 inches high, or any vessel containing 231 cubic inches and no more. I have not room here to do more than notice a curious coincidence between this determination and what was made for the so-called congius of Vespasian, the Roman wine-unit. The proportion between $\frac{1}{8}$ of the Roman cubic foot and Vespasian's measure, is almost exactly as 216 to 231, or as $\frac{1}{8}$ of the English cubic foot to the wine measure of Queen Anne. By what destiny is it that, with nations more than 1600 years apart, there should be this close numerical accord?

A few years after, a statute of 13 Anne legalized the habitual coal-bushel to be of the contents of a Winchester bushel of William III and a quart; cubically, therefore, it would be 2217.62 inches, struck. The phrase of the law, which requires 19.5 inches in diameter from *outside to outside*, had reference to the base of the cone upon which the heap was to be made; for coal was always sold by heaped measure. In practice they had besides a contrivance for making a conical strike.

From this time until the Committee of 1758, there appears to have been no important movement made in regard to the standards. I have already spoken of the labors of this Committee and their late success, with reference to the length-measures and weights: in the capacity-measures, they were even more industrious but less fortunate. Fifty folio pages of research and speculation attest the interest with which they viewed their subject; and a guaging of the old standards in the Exchequer, elaborate and reliable (for it was made by Bird,) have furnished the numerical data to all succeeding inquirers. But their very success in the others, was prejudicial to this part of their examination; the old sterling weights were hidden from them behind the larger troy and avoirdupois, which they found accordant and pervading; and finally, hearing in the old statutes and the new, the perpetual refrein of *one weight and one measure throughout this realm*, they could not, any more than Sir Thomas Powis, comprehend how such *oneness* could co-exist with two different measures called by the same name. Had the half-peck never been named the gallon, their difficulty must have vanished.

Although, therefore, the proportions of 231 and 282 in the wine and ale-gallons confirmed their favorite troy and avoirdupois, they proposed to do away with the former entirely and thus realize the aspirations after *one measure:* they would have pre-

ferred a gallon of 280 inches, as resting both upon a more accurate and convenient arithmetic and upon a more ancient and legal precedent. But this last would have required a new establishment of guaging apparatus for the Customs; the Alicant case, which I have just detailed, came to their assistance to prove that the guage by 282 inches, in legal use for domestic fermented liquors, was also a measure for Spanish wines; neither of the three, separately or together, remained in any useful connection with the bushel, the unit of dry measure; and the Committee therefore recommended the adoption of the gallon of 282 inches as the unit of all liquid measure. They do not appear to have reported any model of this standard, as they did of the yard and troy pound (and as we read in some of the histories of England, they did of all) to Parliament.

Of the immediate event of their recommendations, I have already spoken; as well as of the less marked labors of a Committee in 1790, which followed upon the invitation of the French government in that year, for England to join in the enterprise of an universal uniformity of weights and measures. It was not until 1814, that the question was again taken up and, upon the return of a general peace in 1816, reported to Parliament by a Commons' Committee. I have designedly left this proceeding to be spoken of here; because as regards the positive measures of length and the weights, they were hardly the subject of dis-

cussion. The yard of 36 inches, they thought, should be compared with the pendulum or perhaps an arc of the meridian, or both, with a view to its permanency: and there was a vague proposition, which I have found in the testimony taken about that time, to alter the avoirdupois weight so that the ounce in that system should be really $\frac{1}{1000}$ of the cubic foot of water; as it had, ever since the Oxford experiment, been counted to be. The Committee proposed to attain the same result, by altering the standard temperature of the water from 60° or 62° to 56°.5 F.

Their most important suggestions, however, related to the capacity-measures. Like their predecessors in 1758, they thought there should be but *one measure;* and they proposed its ascertainment by the weight of distilled water it might contain. The weight they recommended, 80 lb. for the bushel at 56°.5 F. which gave the gallon 10 lb. and the quart 40 ounces avoirdupois, and made the half-pint exactly $\frac{1}{100}$ of the cubic foot—seems to have originated with Dr. Wollaston; and the controlling reason appears to have been, "the advantage of making the subordinate measures in integers." Another eminent philosopher, (Professor Playfair) testifying to the Committee, thought "it would be better to take the bushel at 2160 inches; because it differs but little from K. William's Winchester bushel, and because it is in the simple proportion to the cubic foot of

5 to 4;" but he did not seem to be aware that this was in fact the earliest English measure, nor did either of the savans hint to the Committee that they were in substance going back to the old Roman quadrantal.

Such were the influential recommendations which came before the scientific Commissioners appointed by the Government in 1818. Of the results of their investigation touching the other measures, I have already made mention; as to the capacity-measures, they adopted the general principles which one of their number, Wollaston, had already indicated in 1816. A more exact experiment led them to modify some of the details; as, for instance, the temperature and, along with that, the positive cubic capacities. They reported that "the gallon measure should in future be that which contains 10 lb. avoirdupois of water in ordinary circumstances (that is to say the temperature of the water being 62° of Fahrenheit's thermometer, and the barometer 30 inches); and that eight such gallons should be a bushel."

I shall not speculate upon the process of thought by which the Commissioners arrived at these proportions; they did not find fit fully to exhibit its train themselves. It is sufficient to say, that the conclusions of their third and final report made in March 1821, were accepted and affirmed by a select Committee of the Lords about two months afterwards; and that at length, an Act of 5 Geo. IV, in 1824 (to

take effect from 1 January 1826, by a subsequent Act,) legalized these proportions, and declared this gallon so defined, under the name of the Imperial Standard Gallon, to be "the unit and only standard measure of capacity." The Act, however, qualifies this to a certain extent, by saying that it is to be applied to liquids and *unheaped* dry articles; articles habitually sold by *heaped* measure (coal, potatoes, etc.) were to be measured by the bushel of 80 lb., or of 8 such gallons, with a cone of 6 inches in height, and a diameter of base from outside to outside of 19.5 inches, as in Queen Anne's coal-bushel.

Expressed cubically, according to the weight of water as ascertained by the Commissioners, the gallon would contain 277.274 inches very nearly; and the bushel, 2218.19075 inches. These dimensions remain unaltered, so far as I am aware, to this day; though there have been several succeeding laws, restricting or enforcing the terms of the first one, as for instance the Act 4 and 5 William IV, which abolishes *heaped* measure. But as from this point our standards and those of Great Britain diverge, it is not necessary to pursue their history any later. I shall close now what I have thought necessary to be said, by presenting in one page a view of the English capacity-measures in their several successive phases, together with the probable analogies which led to their occurrence.

TABLE *shewing the Values in English cubic Inches of the English Liquid and Dry*

	Wine Measure.		Corn Measure.	
DATE. A. D.	GALLON IN THEORY.	ACTUAL GALLON.	BUSHEL IN THEORY.	ACTUAL BUSHEL.
Ante 1000	216.	. .	2160.	. . . .
1000 — 1266	216.	217.6 Irish gallon.	2126.25	2124 Wm. Rufus, of 1091 2124 Hen. VII, no rim, 1496 2128.9 Elizabeth of 1601
1266 — 1491	217.6	217.6 do.	2142.	2145.6 Winchester bushel; copy for Hen. VII 2150.42 do.; Wm. III, 1696
1491 — 1496	.	. .	. . .	. . . .
1496 — 1705	224.	224 Guildhall gallon.	2205.	2224 Hen. VII, rim, 1496 2217.62 Coal-bushel of Q. Anne, 1712
	224.	224 do.	2177.78	2178 Bush. of Geo. III, 1805
	230.4	231 by 5 Anne, 1705. 231 Exchequ'r gall. 1688?	2240.	2224 Henry VII?
	230.4	231 do.	2268.	. . . .
	231.	231 do.	2245.83	. . . .
1705 — 1822	231.	231.2 Excheq'r gallon, 1707.		2150.42 for Corn 2217.62 for Coal
1822 — 1845	277.274	277.3 Imperial gallon.	2218.19	2218.19 Imperial bushel

Capacity-Measures at different Epochs; and the probable Formulæ of their Variations.

Corn Measure.		
CORN-GALLON = 1-8 OF THE VOLUME OF THE BUSHEL.		FORMULÆ.
THEORY.	ACTUAL.	
270.		Wine-gallon $= \frac{\text{Cubic foot (1728 in.)}}{8}$. Bushel $= 1728 \cdot \frac{1}{1}\frac{5}{2}$. *Earliest Saxon Epoch.*
265.78	266.25 Rumf'd gall. of 1228 264.80 Rumford qt. of 1228	Bushel $= 1728 \cdot \frac{1}{1}\frac{5}{2} \cdot \frac{6}{6}\frac{3}{4}$. *Epoch of the Rumford measures.*
267.75		Wine gallon, $= \frac{1}{8} \cdot \frac{1}{0.9}\frac{7}{9}\frac{2}{3}\frac{8}{3} = 217.5227$. Bushel $= 8 \cdot 217.6 \cdot \frac{1}{1}\frac{5}{2} \cdot \frac{6}{6}\frac{3}{4}$. *Epoch of the Winchester measures.*
. . . . .		*Transition Period.*
275.625	272 Henry VII, 1496?	Wine gallon $= 216 \cdot \frac{7}{6}\frac{0}{7}\frac{0}{3}\frac{0}{0}$. Bushel $= 8 \cdot 224 \cdot \frac{1}{1}\frac{5}{2} \cdot \frac{6}{6}\frac{3}{4}$.
272.22	272 Henry VII, 1496 271 Elizabeth, 1601 EE. 270.4 do. do. E. 272.25 Geo. III, 1805	Bushel $= 8 \cdot 224 \cdot \frac{7}{5}\frac{0}{7}\frac{0}{6}\frac{0}{0}$. Troy and avoirdupois together.
280.	282 Gallon, supposed of Henry VII 280 Eliz. quart of 1601 278.4 do. pints 1601—2	Wine gallon $= 216 \cdot \frac{1}{1}\frac{6}{5}$. Bushel $= 8 \cdot 230.4 \cdot \frac{7}{5}\frac{0}{7}\frac{0}{6}\frac{0}{0}$.
283.5	282 Treasury Ale-gallon?	Bushel $= 8 \cdot 230.4 \cdot \frac{1}{1}\frac{5}{2} \cdot \frac{6}{6}\frac{3}{4}$.
280.73	282 do. do. 1688	Bushel $= 8 \cdot 231 \cdot \frac{7}{5}\frac{0}{7}\frac{0}{6}\frac{0}{0}$.
282.	282 for Ale	*Period of Confusion.* Standards all independent. Ale-gallon copied from Henry VII's bushel combined with the Irish gallon, thus $\frac{2}{8}\frac{1}{}\frac{2}{}\frac{4}{} \cdot \frac{2}{2}\frac{3}{1}\frac{1}{7.6} = 281.85$?
277.274	277.274 Imperial gallon.	*Uniformity of Proportion abolished.* Capacity determined by weight of distilled water at 62° F. 30 B.

I have been thus copious upon the subject of the English capacity-measures, because of its intrinsic interest and the acknowledged extrinsic difficulties besetting it. When I read, in the latest Legislative report upon it, such passages as this: that "the gallon of England was originally identical for all uses, and that variations have arisen, in some cases from accident, in others from fraud," or this: that "the wine-gallon is supposed to have gone on shrinking, until its progress was arrested by a fiscal definition at 231 inches," and saw, how then these last explorers threw away their torches in despair,—I could not but be irresistibly attracted to ruins, which are inscribed in dignified and now venerable statutes as having once contained wisdom-treasure 'of old time,' and in which I think I find the traces of the most beautiful and uniform system that ever regulated commerce between man and man. As far as I am aware, these traces have been indicated but by one, before. Far behind him in all the gifts and accomplishments required for such research, I have had but one advantage, (and I have not knowingly neglected it) that of leisure for patient detail, which varied pursuits and continual public services denied to him.

In calling the Saxon system just now, *uniform*, I did so intentionally and upon reflection. The term, uniformity, can only be predicated of an assemblage of elements or individuals; a single individual, uncontrasted, has nothing to be uniform with. A unit,

in Weight or Measure, may be repeated or multiplied or sub-divided in different parts of the system; and such repetitions are to be called *identical*, and the system itself *unitary;* but as long as our language remains true to its radicals, it can hardly be said to be *uniform.* Besides this, there is another consideration necessary to complete the idea of uniformity in this regard; and this is the correspondence between the weights or measures (which are but the indices or representatives for articles of commerce, grown or manufactured,) and the articles themselves, so indicated or represented. In both these aspects the early English system, prior to the fourteenth century, is more fully uniform than any modern establishment. By it, the properties of numbers, extension, gravity, and content, all conspired to one result; and, wherever applied, reached their results in one way. An arithmetical harmony governed in the sub-division of linear measures, and fixed the number of pounds to the gallon of wine as well as the number of grains in the bushel of wheat; linear extension, defined on a positive standard, measured the content of the gallon and weighed (as it were, in the balance of the sea) the ton; between gravity and content, no more terse and suggestive description of uniformity could be devised than the phrase of the Great Charter which says: 'of weights it shall be as of measures;' and finally, there can be no fuller correspondence between an index and the things indicated, than was

manifested while the respective measures of liquid and dry substances reciprocally served to weigh each other, and the coins, the necessary implements of commerce, weighed both. In this system, uniformity not only co-existed *with*, but existed *because* of the several unitary elements of which it was composed.

If modern establishments lay claim to a similar or paramount uniformity, it must be upon the same principle: but a calm examination might show, I think, that this has not always been attended to; and that people, as Mr. Adams has already remarked, have sometimes taken *uniformity* to be nothing else but *identity*. For such an examination, there is here no occasion; and I shall, therefore, not stop to contrast the Weight and Measure system which we have been contemplating, with (for instance) the newer metrology of France,—where occur two different units, neither derived from nor in any physical correspondence with commercial substances, and where the principal uniformity is in the harmony of decimal progression; nor again with the present establishment of Great Britain,—where there are also two units, and one of them entirely local and not in the present state of science perfectly referable any where else,—where articles, so dissimilar as wine and wheat, coal and potatoes, are rated by one measure and that not founded upon the weight of any one of them, but upon the space occupied by an even (but neither a square nor a cubic) number of pounds of water. I

shall rather proceed to a brief account of the steps which led to the establishment of our own system.

The commercial dependence of the American provinces upon Great Britain, notwithstanding the actual differences in colonial origin of some of them, would naturally tend to a sort of identity with the English standards of Weight and Measure. We have already seen what was the case in Maryland; and in point of fact, at the establishment of the American Confederacy, all of the thirteen States had legalized the measures of England. Five of them had named the Winchester measures in their laws; of the rest, all but one had, under the epithets *Exchequer* or *London*, accepted either the Winchester bushel or one, derived from a gallon of Henry VII, of 2177.78 inches. The single exception was Connecticut, who had taken a gallon of 224 inches for wine and one of 282 inches for ale; this last was intended to be the eighth part in volume of the bushel.

When the States became independent, a zeal for repudiating all old connections possibly augmented the stimulus which at the time, as I have already said, was pervading many parts of the civilized world, towards the research after uniformity and an absolute indelible measure. At all events as early as August 1785, the Board of Treasury was directed to "report an ordinance fixing the standards of Weight and Measure throughout the United States." But

the still revolutionary character of the period and a coming crisis plainly marked, were unpropitious to any immediate result; and, at the adoption of the present Constitution, the matter stood as it had done for years before.

The second session of the First Congress under the Union was held in New York, on 4 Jan. 1790; and five days afterwards, President WASHINGTON in his speech, called the attention of the Legislature particularly to the subject. A suitable reply, promising 'early attention,' was made in the Senate; and in the House of Representatives, an order was passed calling upon the Secretary of State (then Mr. Jefferson) to prepare and report a proper plan or plans for establishing uniformity in the currency, weights, and measures of the United States. Six months later, the report was received by the House where the call had originated; and it was communicated to the Senate on 23 Dec. of the same year, after a fresh special invocation by the President's address upon the subject of which it treated.

This document was quite characteristic of the eminent person by whom it was prepared. An admirer of the French philosophy, he took as the basis of the new system what had been almost simultaneously proposed publicly to the National Assembly of France by Talleyrand; and in the earlier discussions with regard to which, Mr. Jefferson very probably himself assisted during his residence in Paris. This

basis was the second-pendulum, in the parallel of 45° N. latitude. But the report was made before Borda and his colleagues in France had shewn the inferiority, of what may be called a *dynamical*, to a *statical* standard; and the other pursuits of its author had not allowed him to attain sufficient acquaintance with practical science, to be entirely aware of the mechanical difficulties which the plan he proposed would have to encounter, or the uncertainties it must submit to. I believe that not many, at the time or since, have considered as a misfortune that neither of the propositions it contained was adopted.

The report comprehended two distinct plans: 1°. to render uniform and stable the existing system,—by comparing and fixing the unit of length with the pendulum, to which also superficial measures would be referable,—by abolishing the distinction between liquid and dry capacity-measure and fixing the unit of the latter (now to become the unit for both) at some medium term likewise defined by the measure of length, viz: 1.25 cubic feet,—by retaining the more known denominations and proportions of the two systems of weight and referring them (reduced to one series) to a definite volume of some substance, viz: rain water, the specific gravity of which never changes,—and finally, by expressing the quantity of pure silver for the money unit in terms of the weight so defined: or 2°. to attain uniformity by new units, a decimal division, and a partially new nomenclature.

These plans were called alternatives; they might have been termed opposites.

It is not necessary, nor even proper, to enter here farther into the details of the two propositions. The whole report may be regarded as an original document, of illustrious emanation and worthy to be consulted by the curious in such subjects. Even its most valuable suggestion, that of the reciprocity between weights and coin, I consider as in some sense original, too; for there is no evidence in any of its phrases, that such reciprocity was known at the time to have been anciently inherent in the old Saxon system, upon the debris of which our own was working. In other particulars, too, there appears to have been no superfluous research into that early system; only some of the most palpable, modern, or accidental co-incidences are indicated. The gallon for wine, of whatever calibre, is "altogether disregarded, as concerning principally the mercantile and wealthy;" and the wine-gallon of 231 inches, the habitual one in the country, is stated as resting "on the authority of very long usage, before the 5th of Anne, the origin and foundation of which are unknown." In January 1791, a supplemental report corrected a slight arithmetical error which had been committed; and added some developements in regard to the superficial measures under the second plan.

In the House of Representatives, I am not aware that any immediate order was taken; in the Senate

the report and postscript were referred to a Committee who, on 1 March 1791, reported in substance that, regard being had to the steps in progress both in France and England, "it would not be eligible at present to introduce any alteration in the measures and weights which are now used in the United States." This report was adopted.

The Second Congress met at Philadelphia, on 24 Oct. 1791; and on the next day, received an emphatic stimulus upon this subject in the address of General WASHINGTON. Accordingly, in carving out the business of the session, "the fixing the standard" was made the second in order among the topics to be treated by the Senate; and a Committee, raised for the purpose. The report of this Committee, made on 5 April 1792, was, as nearly as might be, a transcript of the second plan of Mr. Jefferson. Its consideration was postponed until the next session of Congress.

At that next session, it was taken up; but the question between the new system it recommended and the existing one, was not easily settled and gave occasion to long debates and repeated postponements. Two substitutes having in view the conservation of the old system, (one of them identical with the first plan of Mr. Jefferson,) and a third, combining in an ingenious manner the existing units with a decimal sub-division and thus melting as it were the two propositions into one,—were successively discussed;

and, after a month, the whole matter was referred to a new committee. The report of this last, made on 29 Jan. 1793, has eluded my search; but ten days after, the entire subject was formally postponed until the next session.

Apparently the difficulties experienced in settlement, overcame the attractiveness of the subject; the first session of the Third Congress passed over without reference to it; and the only notice of it during a second session, was the transmission to the Senate, on 8 Jan. 1795, of a communication from the French Envoy, Fauchet, accompanying copies of the provisional standards according to the metrical system, which had been directed to the American Government by the Committee of public Safety. The Senate ordered the printing of the communication, but took no farther action.

In the House of Representatives, it served as a motive for a Committee to report both upon it and upon the plans which had been submitted by the Secretary of State five years before, and which hitherto seem to have been left in courtesy to the charge of the Senate. On 12 April 1796, this Committee reported. They wisely confined themselves to the enunciation of only the most indisputable principles; and, by the aspect of their conclusions, rather increased the doubts both as to the elements of the question and the attainment of an advantageous result from any change. They preferred the old units

but, if possible, the decimal division; and they desired to do away with the objections to positive (or as the report terms them, *assumed*) standards, by a reference to some uniform principle in Nature, "if it can be made to appear that reference may be had to such a measure, with sufficient certainty of uniformity in the result of different experiments, and without much time, trouble, or expense in making them." By way of trial only, they proposed the following experiments to ascertain: 1°. the length of the second-pendulum in existing feet and inches; 2°. the weight of the thousandth part of the cubic foot of water; and 3°. the respective weights of four different divisions, which they refer to, of the pound and ounce. Nothing actually followed these propositions; and it is curious that cotemporaneously, a private gentleman in England, upon his own means, was undertaking and successfully achieving substantially the same research at which the American Congress, with all the éclat of national effort, aimed and failed.

The subject slumbered now, until the beginning of a new century. On 28 Feb. 1800, the Senate referred to the Secretary of the Treasury (then Mr. Wolcott) "to prepare and report to this House a plan for establishing uniformity in the Weights and Measures of the United States." Such a report was, I believe, never returned: from time to time occasional memorials and motions, as I have before

said, were made to and in Congress; but the breaking out of the war of 1812 repressed even these.

Upon the return of peace, President Madison in his last Message of 3 Dec. 1816, reminded Congress that no adequate provision had been made for the uniformity of Weights and Measures; and he coupled it with a recommendation of the decimal subdivisions, which his predecessors had hitherto abstained from doing, and which seems to me to have been precisely the chief obstacle to the admission of any reformation. The decimal computation is no part of the inheritance of the Saxon Family.

Three months later, 3 March 1817, a resolution reported by the Committee to whom this part of the Message had been given in charge, referred to the Secretary of State, (who was, two days afterwards, Mr. J. Q. Adams) to prepare and report to the Senate a statement relative to the existing standards in the States of the Union, as well as to what had been done in foreign countries towards the aim of uniformity and what would be proper to be done here. A resolution of the same purport was afterwards, on 14 Dec. 1819, adopted by the other House. Before these orders were complied with, (for the field which they authorized was large, and the points to be connected, distant) a Committee-report upon the subject was offered in the House of Representatives, collateral to what had been the main subject of inquiry, viz: the propriety of altering the laws in

regard to domestic or foreign coins. It was on 25 Jan. 1819, that this report was presented. Its conclusions are, in its own words, "that little should be done; that standards conformed to those in most common use among us, should be accurately made and carefully preserved at the seat of Government; that correct models should be placed in different districts of the country; and that the proportions and relations between these, should be ascertained."

This report is a model of calmness and conservatism: too much learning had not confused, nor too wearied reflection led astray. It is easy to see, too, from its tone as well as that of the Senate-resolution just quoted, how the public mind was settling down in aversion to a violent change; what had been found hard of acceptance in 1790, among a people of less than four millions, was now, with a population not far short of ten millions, grown to be nearly impossible.

At length, on 22 Feb. 1821, the report of the Secretary of State was communicated to the Senate. If the report of the former Secretary was characteristic of its author, this was equally so. A combination of acute perception, discriminating judgment, learning varied and rarely at fault, and brilliant diction, renders it attractive beyond its destined sphere. It answered the call and more. In general its conclusions were what might have been expected. It recommended two distinct things, capable of being

carried on simultaneously or separately—one, tending to present improvement,—the other, looking to future perfection. These were, 1°. "to fix the standard with the partial uniformity of which it is susceptible, for the present excluding all innovation; and 2°. to consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity."

The first recommendation has been subsequently in substance realized: it is to be regretted that the second was, at a propitious moment, lost sight of. The report itself exercised a strong influence, in various ways, in bringing about the realization I have spoken of. Deprecating innovation on the ground of both principle and expediency, it attacks from a third position, technically; and it argues, from the literal phrase of the powers conceded to Congress, very fairly (though I doubt if the distinction was in the mind of the framers of the Constitution at the time) that an authority to "*fix* the standard" does not convey one to *unfix:* Congress could repair, but might not subvert—it might reform, but ought not to revolutionize. I believe, too, that most persons rose from the perusal of the document, better content with what we had, and disposed to find, in the aptitude and fecundity once characteristic of the ancient system and capable of being in a degree restored, a compensation for the dazzling but cheerless sameness imparted by a new metrology which, like that

of France, would plant the extremes of its primordial unit of length on either frozen Pole and test its unit of weight by a mass of hardly melting ice.

Such appears to have been the effect upon the House of Representatives, if we may judge by a brief Committee-report upon this document, on 11 March 1822, from the same pen which furnished the report of 1819 to the same body. The Committee thought "it scarcely necessary to do more than submit the resolutions" which were expedient to be passed at the time. They acquiesced in the view of simply rendering "uniform and stable, the Measures and Weights which we at present possess." The troy pound, they considered as already virtually disused in the community; and they proposed to have but one unit of weight,—the avoirdupois pound,—of which, the habitual mint-grain should be the one-seven thousandth part. Contrary to the Secretary's opinion, they desired the standard of length and weight to be made of platina; those of capacity, they supposed, would be best formed of copper or brass. Finally, they proposed a joint resolution by which copies were to be procured on platina, of the Exchequer yard of Q. Elizabeth and of the English avoirdupois pound *in vacuo;* and in any other material, at the discretion of the President, of the standard English wine-gallon and of the Winchester bushel. These when made, "if satisfactory to Congress, should be declared the standard yard, bushel, liquid-

gallon and pound of the United States." The President was besides to have constructed, for distribution among the several States and Territories, models of these standards and of certain subdivisions for each, which are indicated in the resolution: and the system so published was to be left to the good sense and good feeling of the nation for acceptance, uninfluenced by any sovereign requisition or special penalties. But Mr. Adams' proposition for concert with foreign nations, was not mentioned; and as it came to be known shortly after, that Great Britain was about reforming her standards upon principles and elements in some regards the opposite of what would have found favor here,—partly for that reason and partly for some others wholly unconnected with the matter, the resolutions do not appear to have been pressed, and the whole question before Congress was for the present dropped. The steps which had been recently taken were not lost, however; and though they did not reach to the fixing of the standard, they served to fix our ideas about it and became a *point d'appui*, on which subsequent measures rested.

Copies of the Exchequer-standards, of the classes recommended by the Committee, had been procured by the State Department before or about the time of the Secretary's report: there was added to them subsequently, in 1822, a copy of the Elizabethan yard of 1601, not on platina but on brass. This turned out very well accordant, upon a subsequent

comparison with other standards; as did also the weights of the former invoice: but the wine-gallon was found to be of 235.4 inches instead of 231, the corn-gallon of 274.325 instead of 268.8, and the so-called Winchester bushel of 2124.1 instead of 2150.42 cubic inches. It is easy to see, however, that these two last were not inaccuracies in the workmanship, but a mistake in the standard selected to be copied. They had taken the corn-gallon of George III and the small bushel of Henry VII, instead of the Winchester bushel and its appropriate gallon. The coal-bushel of Q. Anne, which should have contained 2217.62 inches, gave only 2211.26 inches. The other suggestions of the Committee, to employ such standards in the making of authentic models for distribution, were not acted upon.

In 1828, after the new British standards had been executed, a copy of the Imperial troy pound, made under direction of and standarded by Captain Kater, was procured for the Mint; and was declared by Congress, on 19 May 1828, to be "the Standard of Weight for the United States; the other weights to be according to their legal proportion to the same." This is, I believe, the only case of express legalization of any specific unit, as yet. Upon comparison shortly after, this pound was found to differ very materially (2.5 grains nearly) from an authentic and carefully made set of grain-weights of Troughton. Such a discrepancy created some surprise at the time, but is

capable of receiving a very distinct explanation. The United States mint-pound was copied from and is identical with the troy pound of the Parliamentary committee of 1758. That Parliamentary pound, made (as I have said) under the direction of the Assay-master of the English mint, was identical with the mint-pound of the same era. But the former, after its construction, did not see the light again for forty years; while the latter was in habitual use for the same term, and gradually lost weight. The grains of Mr. Troughton were derived from the latter; evidently, because there was no other accessible authentic source. So when Sir George Shuckburgh, in 1798, compared the Parliamentary pound with Troughton's grain-weights—he was in fact comparing the mint-pound of 1758 with the mint-pound of 1798, though the experiment was not received in that sense; and he found the last too small. The same result, of course, was shewn with the Troughton weights of Mr. Hassler, which were made not long after and were intended to be identical with those of Shuckburgh. The comparison of Dr. Moll of Utrecht, made about this time, shews the same thing; the elements being reversed. He weighed two English mint-pounds of 1818, copied from the gradually diminishing standard in use, against grain-weights made by the artist Robinson (who furnished the balances for the new English standards of 1824, and whose grains are therefore parts of the pound of

1758) and also against a copy of the imperial pound by the artist Bate, who had made the original. Finally, the English mint itself recognized the difference; and by a notice in July 1833, indicated the deduction (of 1.5 grains to the pound) to be made upon all monies coined prior to 1 Jan. 1826 when, by the Act of 5 Geo. IV, the old weight was directed to be restored. For greater distinctness, I put all these different recognitions together in the table on the side.

Taking, as I do, Troughton's grain weights to represent the weights at the Mint about 1798, the line of differences shews the variations which have occurred there during about a century. In a popular sense, it shews a certain consistency; but scientifically, it is not creditable to the arts applied. For after all the acknowledged deviations are allowed, there still remains a possible unappreciated error of 0.0624 grains, in every copy. It is curious that this is just the minimum possible error which, as Schumacher has shewn, still affects the Imperial standards of weight, in con-

Shuckburgh 1798.	grains.	Hassler 1830.	grains.	Moll 1830.	grains.	Brit. Mint 1833.	grains.
Bird's Parliam't 1 lb.: 1758	5760.000	Kater's Copy for U. S. 1828	5760.00	Robinson's Copy Mint 1818	5760.000	Bate's Copy Mint	5760.00	Since 1826,	5760.0
Troughton's gr.	5763.745	Troughton's gr.	5762.41		5761.515		5761.45	Before "	5761.5
Differences	3.745		2.41		1.515		1.45		1.5

sequence of the omission to ascertain the specific gravity of the metal composing them; and this error may be still farther multiplied by the other omission to observe the barometric heights at the time of comparison. I leave this subject, however, to be considered more in detail hereafter.

A resolution of the Senate, on 29 March 1830, directed the Secretary of the Treasury to cause a comparison to be made of the Weights and Measures used at the different Custom-houses; in view, I believe, of allowing that Department to correct any variations which such a comparison might detect, and thus to introduce a desirable and long-sought uniformity at least in those transactions to which the Government was a party. Under this resolution, the Department engaged the late Mr. Hassler, a person singularly qualified in intellect and experience for the task, to make the necessary examination. In March 1831, the progress in it was communicated to the Senate by a Report from the Treasury: and the next year, two other Reports from the same Department, dated on 20 and 30 June 1832 respectively, covered an elaborate account, by Mr. Hassler, of the general results of the comparison and of the detailed methods for their ascertainment and verification.

The terms employed as standards in this comparison, were ample and authentic; many of them having been brought to this country on the previous selection of Mr. Hassler himself, either for himself

or in behalf of the Survey of the Coast,—to procure the apparatus for which he had, in 1809, revisited Europe. Of the last kind, among the length-measures was a scale of 82 inches divided to tenths, by Mr. Troughton, and in all regards (except length) a fac-simile of Sir George Shuckburgh's scale; of the former—a scale likewise by Troughton, of 52 inches, having the distance 51.2 inches laid off by the same artist from the actual Shuckburgh scale, which thus connected the operation fully with the English determinations concerning the pendulum and yard—an original iron metre from the French Committee of Weights and Measures of 1799, and a toise of Canivet used in the French comparisons of 1791, which thus connected as well with the determinations of the arc of the meridian as with the older system of France. Of course, I do not mention various others, such as the standards in the State Department, all of more or less interest. For the weights, there was the mint-pound which had been legalized by Act of Congress as the Standard; and a set of grain-weights from $\frac{1}{100}$ to 10,000 grains, made originally by Mr. Troughton for Mr. Hassler before 1805 and re-verified by the same artist in 1814, which served to unite with the English system; and an original brass kilogramme of the Committee, which lent the assistance and guarantee of all the physical experiments that had been made for the establishments of the Weights of France.

The variations in the measures of length used by the Custom-houses, from the mean of 36 inches on Troughton's 82-inch scale, were found to extend between 35.76 and 36.165 inches; presenting an extreme error of very nearly $\frac{1}{90}$ of the yard. The weights, which were all avoirdupois, varied from 6830.95 to 7075.52 grains of the mint-pound; thus shewing a discrepancy of 244.57 grains, or of nearly $\frac{1}{28}$ of the unitary weight. The liquid capacity-measures gave for the wine-gallon (although its nominal value, almost universally, was 231 cubic inches) 219.5 and 226.5 inches as the extremes; the smallest deviating 11.5 cubic inches or very nearly $\frac{1}{20}$ from the true unitary capacity. The bushel-measures,—the mean of more than fifty of which, guaged by Mr. Adams' direction in 1820, had been shewn to be 2153 inches, or very little more than 2 inches over the Winchester bushel of William III,—ranged between 2056.29 and 2165.2 cubic inches; giving room for an error, likewise nearly $\frac{1}{20}$ of the true capacity.

Upon these results, which shewed reason enough for the interference of the Government, it was not difficult to adopt the principles that would in future reconcile them. The weight of the Mint was the already-settled standard in that regard; the scale of Troughton, sufficiently authenticated to afford the unit of length; and the desire, which has been shewn to have existed from the beginning, for pre-

serving the mean of the habitual measures of the country, was to be gratified by restoring to the units of liquid and dry capacity the dimensions expressed or implied in many of the Colonial and State Laws. Therefore the Secretary, in his Report of 20 June 1832, expressing the opinion that "the Department has full authority to correct the evil—by causing authentic standards to be supplied to all the Custom-houses," announced in substance the adoption of the Troughton scale aforesaid, as the standard of all linear and cubic dimension; an avoirdupois pound raised from the unitary mint-pound in the proportion of 7000 to 5760, as the standard of commercial weight; and a wine-gallon of 231 and a Winchester bushel of 2150.42 cubic inches, as the standards for liquid and dry capacity, respectively. These last were understood to be determinable from the weight of distilled water they would contain (viz: 8.339 and 77.6274 avoirdupois pounds, respectively) at the temperature of its maximum density, say 39°.8 of Fahrenheit's thermometer; in this particular differing from the English method, where the temperature is taken at 62° of the same scale. In both, the barometer-stand is 30 inches. Mr. Hassler had wished to adopt the point of maximum density as a standard temperature of comparison, throughout; actually, however, it has been applied no farther than to the capacity-measures. It was understood also, that the material of which the standards should

be constructed, a condition evidently not without influence, would be *brass*.

The same Report also announced that the fabrication of the standards was actually in progress at the Arsenal in Washington. Diplomatically speaking such was the fact; practically, the matter had gone no farther than the opening of an extensive correspondence for supplying the requisite materials for the artistical part of the Establishment. Among other things, Mr. Hassler (to whom its superintendence was confided) was very desirous to execute the recommendations of Mr. Adams in extending the comparison to authentic weights and measures of foreign countries;—a step, both of high interest in itself, and absolutely essential (one would think) to a due administration of the commercial regulations of the country. It is to be regretted that his efforts in this regard met with less encouragement and success than they deserved.

The artistical commencement of the work is to be dated in March 1836; after a confirmation and stimulus to the acts of the Department had been given in the passage of a resolution by the House of Representatives; declaring it "highly expedient that the Treasury Department should complete, with as little delay as practicable, the fabrication of standards of Weight and Measure for the supply of the different Custom-houses," upon the principles already set forth. A joint resolution of 14 June 1836, directed

"a complete set of all the Weights and Measures adopted as standards—to be delivered to the Governor of each State in the Union, or such person as he may appoint, for the use of the States respectively;" and on 7 July 1838, a section in the Act for the support of the Military Academy authorized the construction of standard-balances for the several States. This last provision is the only one regarding the State of Maryland, that remains as yet not fully complied with.

Farther particulars touching the fabrication of these standards, it is obvious, belong properly to the account that may be expected in due time from the Establishment where they were made: they form at least no part of this Report. Up to this time, the legal authenticity of the several units may be inferred from the Acts and resolves which I have indicated; but the fidelity with which these units have been reproduced and the absolute value and relative accuracy of the individual standards, can be estimated only by the character of the late Superintendent of their construction. For myself—who knew and appreciated that character and, as an occasional friendly attendant upon all stages of the operation, have been a gratified witness of the integrity and skill of the observer—I receive them with the confidence that personal convictions alone can inspire.

PART III.

OF THE METHODS APPLIED TO THE CONSTRUCTION OF THE STANDARD MEASURES OF LENGTH IN THE PRESENT ESTABLISHMENT.

The Resolution of the General Assembly, which authorized the construction of these standards, and which has been already quoted (*ante*, page 42,) does not by its language imply, much less expressly direct that the State-standards shall be precise *copies*, in all mechanical particulars, of those received from the United States. It prescribes only that the standard value of the several kinds of weights and measures shall be retained and re-presented; and it leaves to be exercised during the construction, a reasonable discretion for introducing such modification of accessory parts and contrivances as that, while the value of the measure (of whatever kind) is strictly preserved, the implement or standard so preserving that value may be suitably adapted, in accuracy, ease of comparison and durability, to the fresh uses for which it is destined—uses which were not so peculiarly the aim of the Weights and Measures furnished by the

United States. These last were principally intended to fix and preserve the standard; ours, to disseminate and make it common. Theirs were for a national establishment; ours, for popular use.

Such at least is the theory of the interpretation which has been given to the resolve of the Legislature. In practice, it has been applied only to the measures of length—in regard to the other kinds there seems to be no occasion; and to what extent, under what necessity, and with what advantage it has been so applied, will appear by the following paragraphs.

1°. *Of the Form of the Yards and their accompanying Apparatus.*

All linear standards, which have been hitherto constructed either for scientific or national purposes (and it might be said, all which can be constructed for either or any purpose) may be grouped into two classes; the first, comprehending all those cases in which the unitary length is defined on the *surface* of the material object representing the standard, by marks, traces, or points; the second, comprehending all those wherein the *substance* or mass of the object representing the standard, is itself cut off to the proper unitary length. Standards of the former class are designated by the French writers on the subject (with more terseness than our language readily ad-

mits in this instance) as *étalons à traits;* standards of the latter, as *étalons à bouts.*

Each of these may be again arranged into different varieties, according to the character of the lines or edges which define the measure respectively: but in regard to standards *à traits*, it need only be said here, that they are wholly inapplicable for popular use; since for comparison either among themselves or with others, they demand an optical apparatus of a somewhat troublesome and peculiar construction and an observer skilled in its management—all which is easier to be spoken of than complied with.

The varieties of the other class,—standards *à bouts*—are more distinctly divisible; inasmuch as they require different methods (either optical or mechanical) for the adjustment and comparison of each. For example, 1°. they may be made so that the bar itself (or a part of it) is cut off to the just length of the unit represented; as is the case with the yard-sticks and foot-rules in common use. These represent the unit *intrinsecally.* Or, 2°. they may be so made that the just length required shall be contained between two pieces projecting from one of the surfaces of the bar, either solid parts of the bar itself or artificially joined to it. These, (after the fashion of the English imperial standards,) represent the unit*e xtrinsecally.* They are, in fact, *matrices.* Or, 3°. the two varieties may be combined (as is the case with the French metres and the United States'

yards) so as to present both the intrinsic unit and its matrix. Or, 4°. the two varieties may be separated, so as to present the just length between the face of one end cut off and of a projection from the other end. This last is the form accepted for the yards of the present establishment.

Each of these varieties has its own peculiar advantages and inconveniences, both in original verification and in subsequent comparison. It is not necessary to criticise in any detail those forms which we have not adopted; I shall, therefore, only indicate the chief merit and defect of each. The first mentioned has the advantage of extreme simplicity; but on the other hand, the trouble in making it, is to prevent its being too short, for the extension under the heat of the hand in the time required for only a minute alteration is greater than the error that, in the present state of the arts, ought to be allowed in a professed standard: and after it is made, every comparison of it with another tends to and actually produces a similar degradation. Standards of this form, therefore, could not be relied upon after any length of time, or much use. The same objection applies, though in just the reverse sense, to the second form mentioned. Here the risk to be guarded against in original construction, is lest they be too long; and every time of being used afterwards, tends to aggravate the characteristic error.

The adoption of the third form as in the United

States' standards, it is obvious, enhances vastly (more than doubles) the cost of construction. If the yard and its matrix be kept together, it is equally obvious that the arrangement passes over into the class of standards *à traits;* which, although the most accurate under microscopic comparison, are, as has been said already, in consequence of the necessity of using that very method of observing, unfit for popular diffusion. In the Instruction accompanying those standards it is said that, for popular comparison, the two pieces are to be carefully separated. In such a state of separation, each is of course liable to the objections which have been already pointed out as attaching to the respective forms; and if the putting together and taking apart are effected frequently, it is to be presumed that not only will the standards be deteriorated for reference asunder, but that the originally fine line of junction will become a gap, unpleasant and untrustworthy for observation together.

These considerations and a good many others induced me to devise and adopt the peculiar form which has been mentioned in the fourth place. This is only an L-shaped bar of brass; $\frac{3}{8}$ of an inch thick, 1 inch wide and 37 inches long: the foot, or part which projects at right angles to the thickness, is 1 inch square. The inner plane or edge of this projection is worked true and square with the axis of the bar; it is the zero of the measure. Similarly true and square, and parallel therefore to this first

plane, is worked the other end of the bar; the distance between the two planes is just the yard.—Each such bar when laid direct, is the counterpart of another with ends reversed; when so placed together, the two form a bar 38 inches long and 2 inches wide. The junction of the alternate ends presents a favourable line for optical determination; and it was in this position and way (as if upon a measure *à traits*) that the yards were actually compared with the standard. For nearer description and details, I refer to the paper printed at the end of this Report; which is in fact a copy of the Instruction sent along with the yards, to guide in their proper employment and that of the accompanying apparatus. I shall only speak, therefore, here in regard to the general principles of the arrangement.

Unlike a mere yard cut to length, which requires in comparison a separate butting-piece against which it and the measure to be compared may press, this has its proper butting-piece in itself and is so far constantly ready for use. Unlike the matrix-standards, which admit in comparison only another measure exactly right or shorter than the true, this admits the laying off of a yard and its subdivisions upon a piece of indefinite length: it is also as easy in this as in any other form, to lay off a succession of yards upon the same piece. And unlike both, which have their respective errors of degradation constantly in the *same* sense, the deteriorations of the extremi-

ties in this occur in *opposite* senses; while the wearing of the end against which the cutter works, tends to shorten the yard, a similar wearing away of the other end against which the measures in comparison are abutted, tends to lengthen the yard; and thus, the amounts of these respective wearings away being ordinarily about equal, the just length is always maintained. At least, it may be reasonably expected to be maintained much longer than with a form which admits of no such compensation. In simplicity of construction, therefore, in facility and, so to speak, fecundity of application and use, in the degree of accuracy obtainable with the least trouble and in the shortest time, and in permanent correctness under actual handling—there is reason to believe that the present form will be found to have combined more advantages than either or any of the others.

I need hardly speak of certain minor advantages, which were contemplated in its design, too;—they are not, however, less real or less proper to be taken in account, because they were not admitted to control the design. Such, for instance, is the œconomy in construction: which arises not only, in the first place, from their being not much required for the artist to do, or in the next, from every thing that is required, happening to come in the easiest manner; but also, and chiefly, from there being no lost work nor possibility of lost pieces. This will perhaps be

better understood by the artist than by the general reader; but it is not the less true for that. It is sufficient to say, that if a yard *à bouts* happens in the process of adjustment to become too short, or equally a matrix-yard to become too long, the pieces are irreclaimable. On the other hand, if a yard of the present form is made too short by the grinding away of one end, the just length can always be restored by a corresponding adjustment of the other. Of other particulars, such as the arrangement of the accompanying apparatus, etc. there is still less occasion to speak; they are only such as flow naturally from and are suitable to the general principles which I have indicated.

2°. *Of the Material of the Standards and of the experiments for Expansion.*

The discretion allowed as to the *form* of the standards, does not apply to the *material* of which they are to be composed. The character of this is determined by the phrase of the Resolution, directing that the State-standards shall be of the *kind* furnished by the United States; and it is no affectation of verbal precision to say that *brass* standards, for instance, are of one kind, and *wooden* or *iron* ones, of another. On the contrary, it is obvious that when one standard or a copy of one professes to represent another or its original, so as to be fit to take the place of that other, they must so represent each other under all

circumstances—they must be (to speak technically) *equivalents*. And they cannot be said to be equivalent, unless the variations in each (for there is no such thing in Nature as absolute repose or freedom from change) occur from the same causes, under the same circumstances, and to the same extent: the affections of both must follow the same law. Thus, to take an example which may illustrate what has been said; suppose the original standard to be of brass and the copy to be of iron, and the latter to have been so adjusted that both shall be of exactly the same length at a given temperature, say 62° F. Then, at any other temperature, in consequence of the different affection of the two metals by heat, they will be no more of the same length: if the temperature be higher than 62°, the original will be longer than the copy; if it be lower than 62°, the copy will become longer than the original. In either case, they have ceased to be equivalents; and there would be a certain discrepancy in attempting to use indifferently one for the other. The amount of this discrepancy is not so much the question, in the theory of the matter, as its existence; but in practice, it is nevertheless quite observable and even serious. To take the case just now of iron and brass yards adjusted to the same length at 62°: if they are again compared in ordinary summer-weather, say 82°, and the brass yard is held still to be 36 inches, the iron

one will be 35.00$\frac{35,0075}{Z}$ inches—a discrepancy intolerable in things professing to be equally standards.

The principal cause of error of this sort, affecting standards of length, is the change of temperature either artificially or in the atmosphere. In standards of weight, it is the change of density in the atmosphere, that is chiefly to be guarded against. With the capacity-measures, errors arise from changes of both density and temperature, and in a duplicate ratio. For cases of absolute necessity, Science in its present state furnishes approximate corrections to reduce and neutralize such errors; but otherwise, by far the best and most reliable resort is to leave them as much as possible out of question, by employing the same material uniformly throughout; and this is what our legislative resolution has discreetly determined, by providing that the copies shall be of the same kind with the original.

Following out these ideas, it would have been desirable for our standards to have had some of the same brass, out of which were made those of the United States; for experience shews variations in the properties of different specimens of the same metal or of what goes under the same generic appellation. And this is especially so in the case of factitious metals or, as they are called ordinarily, alloys; where, even when the constituent proportions are the same and the purity of the elements undoubted, it is yet possible to conceive that the mode of combina-

tion may be affected by a difference (unperceived or disregarded at the time) in the ratio of the imponderable agencies which were at work during the process. But such variations are in effect much below those of which I have been just now speaking. They are generally treated in practice as without the limits of exact observation: but whether this is with reason or not, has not been finally determined.

The new brass, which Mr. Hassler caused to be made for the United States' standards, presents in several physical characters a marked difference from the ordinary brass of commerce; it is softer, freer, more uniform in texture, of a more agreeable color, and oxidates even with a pleasanter aspect. This last particular was a point upon which the late Superintendant, whose remarkable versatility of genius found nothing too great or too small for attention, in a manner piqued himself; and the bright eye of the aged philosopher gleamed brighter as it watched the deepening of what he called his 'ærugo nobilis.' The composition of it was the result of divers trials upon various proportions; and the ingenious and novel methods which had served to furnish its constituent elements, were such as were calculated to produce the zinc, at least, in much more than usual purity. All these peculiarities would have made the employment of such metal, had it been possible, of great interest and advantage: but it was only to be

procured by a repetition of the original processes—a step manifestly disproportioned to the end now in view. Under these circumstances, resort was had to the article as more usually obtained.

This was composed, by weight, of 3 parts of copper and 1 part of zinc, without other alloy. Its specific gravity, hard-hammered as in the actual yards, is 8.4954 times that of distilled water at 71°.375 F. and 30.04 inches of the Barometer. Reduced to a temperature of 62° F. for the expansion of both substances, (the correction for the barometer in the weighings being too remote for application,) this becomes 8.4919. Taking the average specific gravities of copper and zinc, that of the compound would be by theory 8.2464, if there were no change of volume. Berzelius has rated that change of volume at about $\frac{1}{10}$ of the aggregate; but in this case such a ratio cannot apply, for the $\frac{3}{100}$ difference (to make the theoretical equal to the actual specific gravity) is already far within it and, besides the chemical change of volume, has to cover the mechanical condensation produced by the hammering.

The difference between this result and the specific gravity ordinarily assigned to brass, would have been an additional call, if any had been necessary, to enquire into some of the other physical peculiarities of the metal in hand; and principally into the amount of its affection by heat or, technically, its factor for expansion. But this factor is in itself so important

an element in determining the value of the yards, both for the present and in any future comparison, that its ascertainment was regarded in advance as absolutely necessary; and I therefore instituted a particular series of experiments with this view.

The principle upon which these experiments were founded, is less new to Science than its application: both principle and application, however, have been less resorted to in researches of this kind than I think they deserve. It is simply *the determination of volumes by weight*, instead of by any optical or mechanical method. I do not mean to discuss here the merits of any of these methods, or to dwell upon the objections to which they are severally liable. I will only remark that either of the two last requires a special apparatus, more or less complicated and, in proportion to the exactness aimed at, itself exactly made; while that which I have adopted, demands but an accurate balance and weights consistent among themselves. Also in any application of either the microscope or the lever, it is as difficult as necessary to isolate the measuring apparatus from the artificial heat applied to the object whose expansion is to be measured. I do not say that it is impossible to effect such isolation; but I do not believe that it has been usually done, if ever: and hence the varieties and indeterminateness of the results hitherto obtained. On the contrary, in the other, which may be called

the *stathmiometric** method, all such sources of error are absorbed; for the result is determined by the absolute weight of a given mass, which remains constant whether the mass be hot or cold. Finally, in this the *cubic* expansion or change of volume is given directly; while in any of the so-called pyrometric processes, the immediate ascertainment is but of the *linear* expansion i. e. the *extension* properly so called. Of course, whatever errors belong to the actual experiment, they are tripled in the subsequent inference of the expansion. Such appear to me the chief points fit to be considered, in regard to the principle of the method. I defer the mention of some others, also of interest, until the Report hereafter upon the Capacity-measures; where there will be more appropriateness and more room for the discussion of such questions. And to the same place and on the same account, I also postpone the detailed description of the arrangement and of the experiments. I shall only give here, in as few words as possible, an idea of the apparatus; and state the final results, as they have been applied in deducing the value of the measures of length.

To a glass vessel, about 5 inches in diameter and 5.5 inches high, with a hemispherical bottom, and capable of containing nearly 3.5 pounds avoirdupois of distilled water, was fitted a ground brass cover.

* q. d. *σταθμιου-μετρον*; linear measures by the balance, or *volume from weight.*

This cover was pierced in the centre and ground to admit a circular brass collar of 1 inch diameter, which carried two thermometers reading to 400° F.; the bulb of one of which reached nearly to the bottom of the vessel, while that of the other was the same distance in regard to the top. There was also another aperture in the cover to admit the ground end of a glass tube of one-fifth of an inch bore, to serve as the extravasation-tube. This tube was so fitted to a projecting collar in the cover, as that its lower end was exactly even with the lower face of the latter: it then ascended vertically for nearly 3 inches, was then bent horizontally for about 8 inches completely to clear the apparatus, and then bent downwards for 4 inches; so that its outer end was little more than an inch below the level of the inner. The additional length given to this leg, as well as the bore taken for the tube, were both based upon a theoretical calculation of what would be required to neutralize any pressure from expansion, of the liquid to be heated in the vessel. In fact, the calculation seems to have been borne out.

To the lower face of the brass cover, and kept from it by studs of a quarter-inch deep, was screwed another circular brass plate; cut with parallel slits from the circumference towards the centre, first to admit the safe passage of the long thermometer, and secondly to hold, by means of slight grooves worked in them, fourteen pieces of brass, about 4 inches long,

1 inch wide and $\frac{3}{8}$ of an inch thick, and weighing together upwards of 7 pounds. These pieces were in reality portions of bars for actual yards; and had been subject to the same treatment as the yards themselves. The grooves allowed them to be placed and removed at pleasure; when in place, they were about a half inch off from the inner surface of the glass, both bottom and side.

The weight of this apparatus, as well as that of the brass pieces, was then ascertained; and also the weight of the contents of the vessel in distilled water and linseed-oil respectively, both when the brass-pieces were in place and when they were removed. In these weighings (the balances attributable to the State of Maryland not being yet ready) I employed a large balance belonging to the United States' Weight and Measure Establishment; for the permission to use which, I am indebted to the kind intervention of Professor Bache, the present Superintendant of that Establishment. It was deficient in divers little adjustments for farthering the convenience of the operator; but otherwise, there were no defects not remediable by attention and patience. Its results shewed themselves to be quite consistent and reliable. For the lesser weighings, I had a small balance from Mr. Green (to whose intelligence and skill, every part of my work is deeply indebted) which proved of remarkable fitness for the purpose. I shall leave the peculiar tests which I applied to this

balance, the mode of determining its constant of friction and of comparing the theoretical value of its arcs of vibration with the actual, to be introduced hereafter in the Report upon the Measures of Weight; where the properties and habitudes of balances will appropriately come up for consideration.

Linseed-oil was chosen as the liquid proper for measuring the expansion of the metal; because its own boiling point is so much higher, and the ratio of its own expansion was presumed to be more constant, than that of other substances which might be thought of. I have no reason to believe, upon a full discussion of the experiments, that the action of the immersed brass exercised any appreciable influence upon that ratio. Before weighing, the oil was first raised to and kept for a half-hour at a temperature of about 250°, in order to drive off any combined water. It was not subjected to any analysis; because it was obtained fresh from the manufactory of the Messrs. Smiths, of Baltimore, who guaranteed it as free from any adventitious impurity.

The weighings I have mentioned, gave not only the elements for expansion both of linseed-oil and brass, but also for the specific gravity of both substances as compared with distilled water. An idea of the exactness which is attainable by the use of such large quantities as those which were operated on as well as the implements which were employed, may be formed when I say that the specific gravity

of the brass deduced directly from the water-weighings, was 8.49544 and indirectly from oil-weighings reduced to the same temperature, 8.49539. The specific gravity of the oil at 71°.375 F. 30.04 B. was 0.93075: reduced to the temperature of 62° F. without correction for the barometer, it is 0.93315. The volume occupied by the pieces of brass (that of the vessel being taken as unity) was

reduced to 67° from observation at 69° = 0.2504741
observed at 67° in another experiment = 0.2504750

These weighings being completed, the next step was to place the vessel filled with oil, but without the pieces of brass, in a sand-bath over a charcoal-fire. The initial temperature was read on the thermometers at the time of applying the heat; and then as nearly as might be at intervals of every 70°, through the range of the thermometers, the quantity of oil extravasated was weighed. For this, two spherical bottles had been provided, with necks that admitted the outer end of the extravasation-tube before mentioned; and they were alternately substituted at the proper intervals. The rate at which the oil dropped over, was such as to allow this alternate removal and replacement without waste. It is obvious that the ratio of the weight of the included oil at the initial temperature to the weight of oil extravasated at any epoch, is equal to the expansion of linseed-oil in glass for the actual interval. Divided

by the number of degrees in said interval, it is equal to the expansion for one degree.

The same steps repeated, with the difference of the pieces of brass being in place, will of course give the ratio of the joint expansion of linseed-oil and brass. Discounting from this, the ratio already obtained for oil alone, we have left what is due to the expansion of the brass.

The ratio obtained for the oil and here used, is not the *absolute* expansion of linseed-oil; it is, as I have already called it, the expansion of such oil *in glass*. It may be readily made thus absolute, by deducting from it the quantity taken as the expansion of glass. But this was not necessary for the present purpose; the behaviour of the glass and the correction for its actual expansion, being assumed to be identical in both series of experiments.

The range of the temperature for the oil alone was in fact carried, in one set, up to 398° F.; but having reason to conclude, from some symptoms which manifested themselves especially during those series in which the brass was in place, that the equilibrium of temperature in the mass was beginning to be destroyed, I saw fit to reject the observation of this last epoch. For instance, the thermometers, which in the beginning read alike, differed when the mean temperature was about 140°, three or four degrees; and, in one set, more—the shorter one being (as it should be in theory) the higher. They then gradu-

ally came nearer and nearer together, shewing a more and more perfect equilibrium, until about 360° to 370°; when the readings changed their signs, and the lower thermometer shewed the higher temperature. I suppose that by that time, the ratio of the quantities of heat applied had exceeded the conducting powers both of the sand and of the oil, as well as the power of circulation in the latter; and the bottom, therefore, of the bath, which was nearest the fire, became hotter than the sides. In point of fact, however, the ratio of expansion deduced at this highest epoch of 398°, differs very slightly from the others (only in the seventh place of decimals;) but it is affected with a contrary sign—the ratio, having gone on to diminish through all the preceding intervals, in this last increases again.

I now present the final results for both substances.

Expansion of Linseed-oil in glass.

Volume = 1., at 72° F. 29.93 B.

Temperatures.		Ratio of Expansion for 1° F.
From 72° to	144°.25 mean.	0.000406520
72	210. 50	0.000396316
72	281. 50	0.000395280
72	353.	0.000395253
72	398.	0.000397511

In deducing from this series a mean for the absolute expansion of linseed-oil, I should incline to reject the first and last numbers as being too much involved in uncertainties of temperature; although

in reality, the difference will be so small as hardly to be worth the arbitrament. The factor which I actually employed for the absolute expansion of the oil (assuming that of glass to be 0.000014355,) in adjusting the weight of the mass at several initial temperatures varying from 65° to 72°, was 0.00039 for 1° F. This was accepted, in regard both to the possible error of the two extreme observations and to the manifest convergency of the series.

Expansion of Brass, hammered.

Volume 1., at 67° F. 30.08 B.

Temperatures.	Ratio of Expansion for 1° F.	Ratio of Extension for 1° F. Length 1. — at 67° F.
From 67° to 144°	0.000034048	0.000011349
67 210.5	0.000033977	0.000011320
67 284.	0.000033912	0.000011304
67 351.5	0.000033813	0.000011271

The mean of the Extensions in the last column, would result in an expansion of 0.00040725 inch upon the yard for every 1° in temperature. The number actually used in the reductions to correspond with a change of 1°, is 0.000400; which recommended itself by its simplicity and by its being very near the mean of Hassler's, Troughton's, and my own determinations. It is proper to have regard to the results of the two former observers; because those of the first-named are professedly given as applicable to the United States' standards, and those of the second, justly considered among the best we have, may

be fairly attributed to the microscope-bar; which, not treated like the yard-bars, has less claim to be ruled by the index that governs the metal of which they were made.

I said just now that the extension of Hassler was *professedly* applicable to the United States' standard: and it is in so far the fact, since no experiment was had upon the actual metal of those standards, but the factor used for them is derived from pyrometric observations on (I believe, English) brass by Mr. Hassler in 1816, long before the origin of the present establishment. This factor, I think I am authorized in saying, was only used provisionally, until a proper occasion and suitable methods could be taken advantage of, for ascertaining the true one. I have admitted it, therefore, to modify the index of expansion of the present yards, only because I knew it to be a skilful and accurate observation and worthy to furnish, with Mr. Troughton's, a mean extension for average brass, such as the microscope-bar (and even the standard, in default of more precise research) may be classed among.

While upon this point, it will be not amiss to mention an accidental error which has crept in the statement of the extension of the brass yards, both in the Instruction accompanying the standard's certificate and also in the official report upon the same subject. In both, such extension is stated as 0.0003732508 inch upon a yard, for 1° F. It should have been

0.00037832508 inch. The error is not likely to be attended with any ill consequence; but still it is as well to have it pointed out.

3°. *Of the adjustment and verification of the Yards.*

After the bars, cast of the proper shape, had been dressed down to the due guage in width and thickness and brought approximately to the required length, the next step was to work the inner face of the matrix-end to a true plane; at right angles to a line cut longitudinally of the bar, serving as its axis and as the base of the graduations which were afterwards to be inscribed. This line, about an eighth of an inch from the inside-edge, as well as its fellow, which was drawn about the same distance nearer to the middle of the bar, were both parallel, exactly as could be, to the edges. The standard-yard, being now separated from its matrix, allowed the bar so prepared to be adjusted to it. Raised upon a piece of white pine wood of such thickness as to bring its face exactly even with that of the standard, and in the focus of the microscopes,—its matrix-end, embracing the standard, formed at that side an exact joint; while a separate butting-piece, ground to a plane face and capable of being applied at once to the standard and bar together, afforded (when the adjustment was complete and the two measures of the same length) an equally perfect joint at the

other. In this state, they were examined with the microscope, the temperature being chosen as nearly as possible at 62°; and the new yard so adjusted was taken as the guage to which the others were to be worked, without again referring to the standard until the final verification.

The peculiar shape of the yards was calculated, among other things, for the very purpose of their thus serving reciprocally to guage each other; and it can be easily seen that the nicety and perfection of the contact when both bars are at the same temperature, afford to the artist all that can be desired for guiding his work. In fact, experience shews that they were all capable of being brought by this method within $\frac{1}{20000}$ of an inch of the just length. No bar, however, was allowed to be worked upon twice in the same day; otherwise, there would have been no assurance of an equilibrium of temperature.

After this, the graduation to tenths (and for the first tenth to hundredths) of yards was copied under the microscope from the standard, in the space included between the parallel axial lines before spoken of. The zero for this graduation was a line which had been cut on purpose, and which was a prolongation of the line down to which the plane of the matrix-end had been worked. The graduation of inches was subsequently applied. Though not upon the standard, it was such a point as was presumed to be among the discretionary ones; and its interest, in

the subsequent popular use of the standard, was so manifest as to induce me to execute it. Had the question arisen with me in the preparation of original standards, I confess I could never so far have repudiated a proveable antiquity of more than a thousand years, as to have left out, in the presentation of a Saxon yard, its habitual subdivision in inches. On this account, therefore, I was the more ready to restore the old connections by the additional graduation.

The decimal graduation was put upon the United States' yard, principally for the use of the Custom-houses. I presume it is employed there to facilitate the reduction of linear measures to wine-gallons; the proportion between a wine-gallon and a cubic yard being sufficiently near a whole number to be taken as such, without material error. There might have been besides, on the part of the late Superintendant, a lingering fondness from former associations for decimal subdivisions in general. But whatever may be the impulse or the utility in the division to tenths upon these standards, it might have been dispensed with upon ours and would have been except that, in point of fact, it was easier to be put on than explained, in case of question, why it was left off.

The perpendicularity of the lines in all these graduations, (or rather of motion in the tracer by which all the lines were cut) was assured by cutting, with the whole movement of the implement, fine lines on the two faces of a clear plate of mica, until they en-

tirely coincided. The faces of the mica for this purpose should be even, and one edge should be straight; the rest of the figure is indifferent. Such are the principal points requiring mention in the account of the adjustment of the yards.

For their final verification, I made use of a microscopic apparatus, similar in general arrangement to that which was employed by Mr. Hassler; and which will be found described in his Report of June 1832, already referred to. The bar supporting the microscopes, being intended only for comparisons of yards, was not much more than half the length of Mr. Hassler's; which was to take in double-metres. The microscopes were of the usual construction, with Ramsden's eye-pieces; they magnified, when adjusted to the focus of my sight (which is about three inches for distinct vision of minute objects,) lineally 19 times and superficially, rather more than 360 times. Both of them had micrometers attached; and I am confirmed by experience in the opinion, which I had before, of the importance of this addition, both to the facility and accuracy of the observation. The method of sliding the measure under comparison along the stand, until its zero corresponds with fixed cross-hairs in the microscope, is excessively tedious and wastes time that might be better devoted in other parts of the operation; and as for accuracy of coincidence, one is, in plain reason, much more likely to be exact in effecting minute

translations in space (as, for instance, through the $\frac{1}{10000}$ of an inch) by the motion of a fine screw than by the pushing or the hammering of a heavy bar. As far as I can estimate from many trials, the chances of equal accuracy in this point by the two methods is about as 6 to 100; and of the six times, in which an optical contact will be made satisfactorily by the motion of the bar itself, *two* will be accidental,—that is, the contact will have been effected when you did not expect it.

The micrometers being turned conversely, i. e their graduated heads both outward or both inward as may be preferred, and the signs + or — being marked on the proper sides of zero, according to position, once for all,—there is no possibility of confusion in keeping the run of the two, any more than if there was but one. In the present instance, the micrometer-heads were both outward; and both standing at zero upon the standard, the algebraic sum of their readings upon any other yard, represented the errors of that yard. Also, if such sum came out with a *minus* sign, it signified the yard itself to be too *long;* if with a *plus* sign, to be too *short.*

The micrometers were intended to read the $\frac{1}{20000}$ of an inch. So, the threads of the screws being about 78 to the inch, the head of the micrometer was divided into 120 parts instead of 100, as usual; in order to restore the required decimal. Afterwards, in the actual adjustment of the glasses, the

micrometers were purposely left to read (as they naturally would) a little differently; in order to disembarrass the observations from any prepossession or reliance upon the same run of the numbers in the different microscopes. The ultimate value adopted, exact to the sixth place of decimals, (or millionths of an inch) was for

micrometer A : 0.000054 in.
micrometer B : 0.000056 in.

A greater difference of readings would have been desirable; but these suited best with the optical focus of the cross-hairs and the divisions.

The whole apparatus was sustained by, and the observations made on a marble slab; the upper surface of which was, with great pains and repeated trials, ground to a perfectly uniform plane, and then polished. Set upon two strong tressels, it was carefully levelled in all directions, and well-braced. This material was preferred to wood, because of the liability of the latter to change its face by local shrinkages in seasoning. Considering the length of time necessary for the numerous observations which were required, a wooden table for the purpose was absolutely inapplicable. Captain Kater has already signalized the grievous error he was near committing, in the Russian copy of the Imperial standard, from inattention at first to this particular.

The method to which he resorted for obviating errors of this kind, viz: the cutting away of the ex-

tremities of the measure down to, or about, the neutral axis of the bar,—could not be applied in this case: but I consider that they are equally obviated, first by the elaboration and (I may say) perfection of the plane on which the measures rested, and secondly, by the results of the peculiar combinatory mode in which those measures were read.

The surface of the marble was *polished*, in order to secure an easy and agreeable movement of the pieces, which in their combination required frequent changings; and this, not out of respect only to the surface of the standards but to the accuracy of measurement, flowing from the perfect adjustment of every part. For the comparisons, the brackets that carried the microscopes, and whose proportions made the axis of collimation of each, equidistant from the anterior edge of the bar supporting them, were so shifted in the slots of their pedestals as that microscope A was $\frac{1}{8}$ of an inch in advance of the other, marked B. They were then carefully adjusted at right angles to the bar. This last was determined by similar means to those which had been employed in making the motion of the tracer, perpendicular. And the microscopes were turned in their collars, until the perpendicular line visible on both sides of the plate of mica bisected the angle (about 30°) of the cross-hairs. This position of the microscopes threw the measurement of course $\frac{1}{16}$ of an inch, on both sides, out of the axis of the standard; which

axis may be assumed to intersect midway the lines formed by the junction of the yard and its matrix. But it was ascertained, by moving the standard to different distances from the edge of the microscope-bar, still keeping it parallel so as to bring successively every part of the lines aforesaid under the microscopes, that those lines had been worked so parallel as to present no appreciable difference till at the very extremities, where the contact did not present a fair line for observation. Also, in all these positions, the lines continued to bisect, satisfactorily enough, the cross-hairs. In so far, therefore, the adjustments of the microscope served as a test for the artistical workmanship of the standard. Whether in an extreme case, that of measuring with microscopes duly adjusted and reading near the opposite diagonal corners, the test would have equally applied, there was no opportunity for observing; nor indeed was it of any interest.

When, then, the lines of the standard brought to its normal position, (i. e. at such distance from the microscope-bar, that the readings were $\frac{1}{16}$ of an inch respectively above and below its axis,) bisected the cross-hairs, the micrometer-heads were set to zero; the standard was moved nearer to the bar; and in its stead were placed two of the yards, fully supported upon the piece of white pine before mentioned, and mutually interlocked, in the way that I have already mentioned. I did not mention before, however, that

the microscope-bar was the farthest off from the observer; with the standard and the yards to be observed, between. This position was chosen in order to produce a compensation for temperature; the remoteness of the microscopic apparatus in some degree balancing against the longer time that it was subject to the radiation from the person of the operator. But even these precautions, though I believe they palliated, could not prevent, in the course of some hours, a visible difference of temperature.

The reason, now, for the dislocation of the microscopes will be apparent. It was to secure a reading upon the butting planes of the mutually interlocked yards, at a point where such reading would be under the best circumstances and nearest to the axis of the yard. The true axis, both as regards symmetry of position and the direction along which the original mean length will be longest preserved, coincides with the interior edge of the bar; but it would have been unsuitable to measure here, because this is precisely the line that would have been embarrassed at both ends by any imperfect junction of the solid with the re-entering angles of the bars. And it is next to impossible, (as may be easily conceived,) even working at an indefinite cost, to make a number of bars so minutely perfect as that their corners should fit, each to each indifferently, exactly alike, or that an irregularity in their angular junctions should not be manifest under a high magnifying power. The actual

axis of measurement, then, was chosen at $\frac{1}{16}$ of an inch within the true; it passes, therefore, midway along the scale of inches; and the same reliance is to be placed upon the parallelism of the planes in these yards, as in those of the U. S. standard.

Further, in yards of the present shape, what is wanted to determine their value, is the mean distance apart of the end-planes. These planes were intended to be perfectly vertical; and they are so in fact, to a very great exactness—I may say, greater than exists in the same regard in the U. S. standard. But I would not, without a more profound detail and elaboration of tests, than I thought it requisite to apply, assume them to be absolutely perfect. I preferred to correct the errors, where they might exist, by the method of observation; for which also, the form of the yards peculiarly served.

This method was, to regard all the other yards combined with a given one (for instance No. 1) as so many butting-pieces; applied more advantageously than if they were independent and separate. Thus, in point of fact, the yard marked No. 1 was combined with all the others; and the value accepted for it was the mean of more than fifty readings, the difference between the greatest and least of which was yet within $\frac{1}{10000}$ of an inch. I believe that its value, thus derived, will be considered much nearer the truth than if it had been obtained in any other more usual manner.

For, had ordinary butting-pieces been used, the resulting value would have been counted upon the *surface* of the yard; which is precisely that part that will not be taken, in the subsequent popular comparison. And this would be the case, had the readings been made at various corresponding points on the upper and under surface. Such readings would have given four (or more) values for the edges of the end-planes, and would test the parallelism of the planes themselves; but would still leave possible an undetected difference in the centre of those planes, which centre will be in general the zero-point used.

Moreover in the employment of a constant butting-piece, its error must be either assumed as *null*, or it will be a constant error, uncompensated for. The former assumption, in any physical experiment, is at least unsafe; while to admit an error without endeavor to compensate for it, is still worse. In fact, there being necessarily two butting-pieces, the chances of error in this respect are doubled; and the error itself not always diminished. In the present comparisons, however, the desirable compensation is afforded; first, by there being such a number of butting-pieces, that this error (whatever it may be) is not constant, but on the contrary, may be fairly expected to occur in opposite senses; and secondly, by the errors being themselves developed and allowed for in the appropriate value of each particular yard. The only pre-

sumption in the case, is that the errors of the planes will affect the visible junction of the pieces, whether they arise from want of verticality, from sphericity in either sense, or from some accidental and foreign irregularity. That the dust, deposited from the atmosphere of the apparatus-room in the course of a few days only, would so affect the junction, I had abundant opportunities of observing.

Leaving these discussions, however, and coming to the actual details of the process, the yard numbered 1 was compared with the standard, in combination with all the others. There were thirty-two in all; of which thirty were for the immediate purpose of distribution, and the spare ones were made as well for future need as against a possible present one. But No. 30^2 was only worked to length, in order to serve as a combination-bar: it did not receive all the graduations made upon the others. It so happened that only twenty-seven of these were used with No. 1; and their mean in two positions (to equalize the illumination of the lines) gave a final reading of —0,000203 inches, or very nearly $\frac{2}{10000}$ of an inch too long.

As an illustration of the method and order of observing, I give here an extract from the Journal for part of two days; to present it in full would needlessly swell this already too long Report.

Extract from the Journal; shewing the mode of registering the Comparisons.

YARDS combined.	TEMPERATURE			Mic. A: 1d=0.000054		Mic. B.: 1d=0.000056		Reductions.	Means.	Ext. 1°F = 0′.000400		Corrected means.
	Bar.	U. S. Stdd.	Yards.	reading	in inches.	reading	in inches.			temp.	correction.	
U. S. Stdd.	51°.5	51°.5	. .	0	.	0	.	.	.	.	.	.
Nos. 1 & 2	.	.	52°. 52°.	— 7.	— 0.000378	+ 9.	+ 0.000504	+ 0.000126				
reversed	.	.	. .	— 2.5	— 0.000135	+ 4.	+ 0.000224	+ 0.000089	+ 0.000108	+ 0.5	+ 0.000200	+ 0.000308
Nos. 1 & 3	52 .	52 .	52 . 51.75	— 18.	— 0.000972	+ 9.	+ 0.000504	— 0.000468				
reversed	.	.	. .	— 4.	— 0.000216	— 5.	— 0.000280	— 0.000496	— 0.000482	— 0.125	— 0.000050	— 0.000532
Nos. 1 & 4	.	.	. .	— 4.	— 0.000216	+ 2.	+ 0.000112	— 0.000104				
reversed	.	.	. .	— 7.	— 0.000378	+ 4.	+ 0.000224	— 0.000154	— 0.000129	— 0.125	— 0.000050	— 0.000179
Nos. 1 & 5	.	.	. .	— 9.	— 0.000486	+ 8.5	+ 0.000476	— 0.000010				
reversed	.	.	. .	— 9.	— 0.000486	+ 8.5	+ 0.000476	— 0.000010	— 0.000010	— 0.125	— 0.000050	— 0.000060
U. S. Stdd.	.	.	. .	+ 2.	+ 0.000108	— 1.5	— 0.000084	.				
do.	51.75	51.75	. .	0	.	0	.	.				
Nos. 1 & 6	.	.	52 . 52 .	— 21.5	— 0.001161	+ 13.	+ 0.000728	— 0.000433				
reversed	.	.	. .	— 21.	— 0.001134	+ 13.	+ 0.000728	— 0.000406	— 0.000420	+ 0.25	+ 0.000100	— 0.000320

The column for Date is necessarily omitted. The first ten observations were made on Wednesday, 12 March, the others on Thursday, 13 March, last.
In the columns for temperature, a number rules until another is given below. The temperature of the yards in the 4th, correspond with their position in the 1st column.

This No. 1 was the only yard that required to be so extensively combined. Its results, it is manifest, gave not only a number of values for that single one; but also a single value for each of the others. By these values, were determined the slight alterations, that were necessary in some of them, to bring them all within $\frac{1}{20000}$ of an inch + or — of the standard. They were then (excluding No. 1) grouped together by fours; or, in other words, the four nearest of one length were combined together. This number in a groupe was taken, to afford a sufficient variety of contacts; the identity in length, to ensure perfection in the contact. But as it happened sometimes that identity of thickness, as well as of length, was wanting for such perfection, so it became necessary in some cases to overrun the original groupe. The average number of observations for each, turned out to be *five;* some had as many at nine; none, less than four.

From each groupe, then, I selected (still excluding the combination with No. 1) *three* readings; in which the joints of the bars had presented the best contact, and which therefore were also the most accordant. I should have considered, had it been necessary, this last circumstance admissible as one of the principles of selection; but in fact, there was no occasion. The discord of the observations throughout was less than the correction for a difference of temperature of 1° F. Such a correction, the maxi-

mum applied, shewed, of course, the maximum limit within which it was allowable to take a mean. The average of these three readings gave an independent mean value for each yard.

I did not comprehend in this mean, the value which had been found by combination with No. 1; I reserved this last for another application, viz: the correction of each yard, considered as a butting-piece. The determination of this correction is only the resolution of the problem:—*to find in the joining line of the butting-planes respectively, the point at which the reading should be taken;* and where it would have been taken, had each yard, used as a butting-piece for any other, been (what it aimed to be) an exact yard. It is, in other words, a reduction of results, abstraction being made of the accidental faults of workmanship; which faults are seen under different phases and therefore submit themselves to calculation, in a series of observations systematically varied and combined. Habitually in practice, the cross-hairs of the microscope are made to bisect the joining-line of the butting-planes; and the possible error between the half-width* of that line and the real zero of either plane, is disregarded.

* In the most glaringly wide joint which I had occasion to notice, I endeavored to measure the width from edge to edge; deadening the irradiations and bringing up the image of the edges quite clearly by means of a piece of white paper, with which I veiled in part the field of the object glass. The quantity read, was 12 divisions on microm. A, equal to 0.000648 inch. This gives the extremest scope of the problem.

This, in the case where the measure is *à traits*, is perfectly proper; because the true zero is really in the middle of the trace. And it is allowable also in measures *à bouts*, either whenever the measure professes to refer only to the surface, or whenever the same butting-piece is to be constantly used; in the latter case, because every subsequent comparison will be upon the middle of the same line which was bisected in the original determination; and in the former, because it is very possible to make the contact of two mere edges so minute as to be masked by the finest spider-line in a microscope. But when the question comes to be, to make four planes so perfect that both horizontally and vertically they shall coincide and be as one, the artistical difficulties are vastly enhanced; and unless those difficulties be met and overcome, (which is not professed in the present case,) it seems to me absolutely imperative that allowance be made for the width of the line of junction. This is precisely, therefore, what has been done.

The mode of deducing and applying the correction, appears very plainly in reflecting upon the nature and origin of the errors. For instance, it is very easy to conceive a combination of two yards of the present form; one of which shall be a certain minute quantity longer, and the other, the same quantity shorter, than the standard. When they are compared with the standard, the reading will be the same as that of the standard; and this, if uncor-

rected, would shew both to be of the right length; although, by the hypothesis, one is too long and the other equally too short. Thus a reading would be accepted for both, which is true for neither. Again, if a yard which is short by a certain small quantity (ε) be combined with an exact yard and both be compared with the standard, the immediate reading will shew both to be short by a certain quantity ($\frac{\varepsilon}{2}$); although in fact, one is exactly right and the other wrong by double the quantity read off. The same thing will occur, only in the opposite sense, with a yard too long. Thus yard No. 1, which was accepted as about $\frac{2}{10000}$ of an inch too long, has affected erroneously, and in the sense of excess, every reading made in combination with it, by $\frac{1}{10000}$ of an inch. In general, every combination of a yard in excess, tends to give the reading too long; every combination of a yard in defect, to make the reading too short. And the reading is to be corrected, therefore, by subtracting the half-sum of the errors, on whichever side they may be. Or, to express it by symbols and with the signs as I used them, if μ be the ultimate reduction of the micrometer-readings, ε the quantity in defect, and $-\eta$ the quantity in excess; the corrected reading, m, will be found by making

$$m = \mu - \left(\frac{\varepsilon - \eta}{2}\right)$$

Of course in each equation, regard must be had to

the signs of the micrometer-readings, (which are here given positive,) as well to those of the numerator of the fractional correction.

It was upon these considerations and in this manner, that the corrections were applied throughout. The value given for any yard by combination with No. 1, corrected for the excess of said No. 1, gave the elementary correction for it; to be used with the similar correction ascribed to the three other yards with which it was independently combined. The number of such independent combinations being (say) 32, with 3 in each groupe, and the number of combinations with No. 1 being 32 also, it follows that the correction makes itself felt in very nearly 200 different cases; and, the differences produced by it being all far within the maximum correction for temperature, it follows also that the chance of error in any one corrected value, is the $\frac{1}{200}$ of the possible error in its direct readings.

I shall only offer farther, in illustration, the actual process for one groupe of cases.

Extract from the Journal; shewing the method of Correcting the readings.

No. 5, *correction* : $\varepsilon = +\ 0.000042$.

	readings in inches.	corrections.	sum of corr.	corr. reading.
with No. 7.	$+\ 0.000146$:	$+\ 0.000051 + 0.000021$:	$+\ 0.000072$:	$+\ 0.000074$
" 13.	$+\ 0.000470$:	$+\ 0.000019 + 0.000021$:	$+\ 0.000040$:	$+\ 0.000430$
" 22.	$+\ 0.000316$:	$-\ 0.000114 + 0.000021$:	$-\ 0.000093$:	$+\ 0.000409$
mean	$+\ 0.000311$		corrected mean	$+\ 0.000304$

No. 7, *correction* : $\varepsilon = +\ 0.0000102$.

	readings in inches.	corrections.	sum of corr.	corr. reading.
with No. 5.	+ 0.000146	as before		+ 0.000074
" 30.	+ 0.000088 :	0.000000 + 0.000051 :	+ 0.000051 :	+ 0.000037
" $\frac{2}{3}\frac{2}{0}$.	+ 0.000112 :	— 0.000019 + 0.000051 .	+ 0.000032 :	+ 0.000080
mean	+ 0.000115		corrected mean	+ 0.000064

No. 13, *correction* : $\varepsilon = +\ 0.000038$.

with No. 5.	+ 0.000470	as before		: + 0.000430
" 7.	+ 0.000372 :	+ 0.000051 + 0.000019 :	+ 0.000070 :	+ 0.000302
" 22.	+ 0.000439 :	— 0.000115 + 0.000019 :	— 0.000096 :	+ 0.000535
mean	+ 0.000427		corrected mean	+ 0.000422

No. 22, *correction* : $\eta = -\ 0.000230$.

with No. 5.	+ 0.000316	as before		+ 0.000409
" 13.	+ 0.000439	as before		+ 0.000535
" 16.	+ 0.000452 :	+ 0.000055 — 0.000115 :	— 0.000060 :	+ 0.000512
mean	+ 0.000402		corrected mean	+ 0.000485

I think it will be manifest now, that in this way the several yards have been made to develope their own errors; and to measure themselves in the same manner in which, as standards, they will hereafter measure the yards in common use that may be applied to them. It only remains to present in one view, the final value of each; as compared with the United States standard, and also with the absolute mean yard which it and they all aim to represent.

The certificate accompanying the U. S. standard states its excess above the mean yard to be — 0.000307 inch; and a memorandum is given of the comparison with Troughton's scale having been made at a temperature of 63°.27 F. By the nearness of the deci-

mal, which could not have been read on the thermometers, this was most likely a mean temperature; from which neither of the pieces varied materially. And it was proper to state the temperature, in view of a future ascertainment of the expansion; when the reading might, if necessary, be reduced to the standard temperature of 62° F. In such near temperatures, however, the ratios of expansion of different kinds of brass would not vary appreciably; and the chief motive in noting it was, I presume, for the use of comparisons that might hereafter be made with copies of a different metal. I should nevertheless, had there been any means of knowing positively the expansion of Mr. Hassler's brass, have thought it fit to have applied the correction in the present comparisons; for the most of them were made at temperatures of 51° to 53°.5, between which and 63°.27 the difference is enough to make a variation in rational expansion quite sensible. Taking Hassler's prescribed factor and my own ascertained one respectively, the variation upon the yard at 52°.25, is upwards of $\frac{2}{1000}$ of an inch,—a quantity fully observable. I did not, however, consider myself justified at present in admitting the former factor; and although, from the whole scope of all the observations, I esteem the real expansion of the U. S. standard as higher (instead of lower) than our own, I regarded all the pieces employed, as being influenced by changes of temperature uniformly, and

expanding or contracting at the same rate. The values of the present yards, therefore, which are given below, are to be considered as referring to the standard temperature of 62° F.

Table shewing the final Value of the Yards.

No.	readings in excess or defect of the U. S. Standard.	Value in inches in regard to U. S. Standard.	Correction for excess of U. S. Standard.	Value in inches in regard to the Legal mean Yard.
1.	— 0.000203	36.000203	— 0.000307	36.000510
2.	+ 0.000113	35.999887	.	36.000194
3.	— 0.000048	36.000048	.	36.000355
4.	+ 0.000122	35.999878	.	36.000185
5.	+ 0.000304	35.999696	.	36.000003
6.	— 0.000130	36.000130	.	36.000437
7.	+ 0.000061	35.999939	.	36.000246
8.	+ 0.000280	35.999720	.	36.000027
9.	— 0.000046	36.000046	.	36.000353
10.	+ 0.000208	35.999792	.	36.000099
11.	— 0.000027	36.000027	.	36.000334
12.	+ 0.000200	35.999800	.	36.000107
13.	+ 0.000422	35.999578	.	35.999885
14.	+ 0.000185	35.999815	.	36.000122
15.	+ 0.000156	35.999844	.	36.000151
16.	+ 0.000385	35.999615	.	35.999922
17.	+ 0.000163	35.999837	.	36.000144
18.	+ 0.000419	35.999581	.	35.999888
19.	+ 0.000235	35.999765	.	36.000072
20.	+ 0.000471	35.999529	.	35.999836
21.	+ 0.000314	35.999686	.	35.999993
22.	+ 0.000485	35.999515	.	35.999822
23.	+ 0.000123	35.999877	.	36.000184
24.	+ 0.000266	35.999734	.	36.000041
25.	+ 0.000302	35.999698	.	36.000005
26.	— 0.000196	36.000196	.	36.000503
27.	+ 0.000007	35.999993	.	36.000300
28.	— 0.000182	36.000182	.	36.000489
29.	— 0.000132	36.000132	.	36.000439
30.	+ 0.000179	35.999821	.	36.000128
30^1.	+ 0.000258	35.999742	.	36.000049
30^2.	+ 0.000109	35.999891	.	36.000198

EXPLANATION OF THE APPARATUS ACCOMPANYING THE STANDARD-YARDS; WITH INSTRUCTIONS AS TO SAFE-KEEPING AND USE IN COMPARISONS.

The standard is enclosed in a mahogany-box; which, unless in use, should be kept fastened by all its clasps and laid away in its outer soft-wood case.

The standard is retained in place in the box by means of two brass pins underneath; which enter two holes symmetrically worked in its lower face. The butting-ends are thus kept from contact with any part of the box.

The lid of the box is always supposed to be opened *from* you. In this position the matrix-end of the standard is on the left-hand. The block of wood, immediately adjoining (but not touching) the matrix-end on its right, is moveable upon being lifted vertically. The object of this block is to protect the face of the matrix-end. Care should be taken in removing and replacing it, not to let it touch that face.

To the right of the other end of the standard and at the extreme right of the box, there is a hard-steel cutter; and beneath it a brass square, with a handle. It is rebated on its under-face, so as to fit on and be guided by the inner edge of the standard. On its outer arm, there is a bevelled cut; in the centre of which a strong line has been drawn. If the square be applied to the standard, and this line be made to correspond with one that will be found about $\frac{3}{8}$ of an inch from the right-hand end of the standard and reaching nearly half-way across, the square edge and the end of the standard will be exactly in the same vertical place. After the cutter is taken up, the square can be lifted out by its handle.

The bed for the cutter is a moveable block; which can itself be lifted, like the block at the other end of the box. When both are so lifted out, there is no obstacle to a rod or bar, of any length, being applied at one extremity to the matrix-end of, and being laid parallel with, the standard.

In the pit, enclosed between these two blocks, there are four loose slips of mahogany, lettered A, B, C and D, respectively.

They are intended for being placed, as required, under the yard-stick or measure to be compared; in order to raise its face even with that of the standard. When the lid is shut down and clamped, it keeps them fast in the pit.

INSTRUCTIONS.

1. Do not touch the standard with an uncovered hand.

2. Do not touch it at all, when it is about to be used in comparison; otherwise than to wipe its surface and ends lightly, if it appears necessary. There will be, in general, no occasion for taking the standard apart from the apparatus. If it must be so taken apart however at any time, first take out every other moveable piece about the apparatus; then shut down and clamp the lid; turn the box over on the top, unclamp, and lift up the bottom as if it were the lid. The standard will be now found detached, lying on its face.

3. For thus wiping it, use a piece of doe-skin, chamois, or other soft leather.

4. For comparisons (in trying a common yard-stick, for instance,) the proper method is as follows: Open the box with its lid from you: take out all moveable pieces: lay the yard-stick in the pit (but not touching the matrix-end of the standard) to see the difference in thickness between that and the standard: make up that difference with some or all of the lettered slips, so that the faces of the standard and the yard-stick shall come to be even: take the brass-square by its handle and apply it to the interior edge of the standard, pressing the yard-stick against it at the same time—the rebate keeps the yard-stick at the proper distance from the standard: slide the square along the standard for a foot or two, and the yard-stick will become parallel with the standard: keeping it parallel, push its left end gently against the matrix-end of the standard; slide the square to the other end of the standard; make the lines on it and on the standard before spoken of to coincide; and you have, by the edge of the square, the line of the true yard. If the yard-stick falls to the left hand of that line, it is too short; and it should be rejected. If on the other hand it is too long,—holding every thing firmly by the left hand resting on the square, take the steel cutter

in the right hand and by that portion of the square edge resting on the yard-stick, cut the line of the true yard; down to which the stick may be afterwards rasped and filed.

5. The same method of placing the measure and of using the square and cutter, of course, applies to the obtaining of any distance (other than a yard) which is graduated on the standard: only, in this case, the square *edge* must be made to coincide with the graduations—the line for the yard is inapplicable.

6. To save time and trouble in substituting the lettered pieces, for bringing the faces of the yard-stick or foot rule in comparison even with that of the standard, use the following table:

If the measure be	take	If the measure be	take
$\frac{1}{8}$ inch thick,	A + B + C + D	$\frac{9}{16}$ inch thick,	B + C
$\frac{1}{4}$ . . .	B + C + D	$\frac{5}{8}$ . . .	A + C
$\frac{5}{16}$ . . .	A + C + D	$\frac{11}{16}$ . . .	D
$\frac{3}{8}$ . . .	A + B + D	$\frac{3}{4}$ . . .	C
$\frac{7}{16}$ . . .	C + D	$\frac{13}{16}$ . . .	B
$\frac{1}{2}$ . . .	B + D	$\frac{7}{8}$ . . .	A

A measure of $\frac{1}{16}$ thick, will hardly come into comparison; and one of $\frac{3}{16}$, could not have been provided for without a special additional piece. In either case, however, the combination of *all* the pieces will answer.